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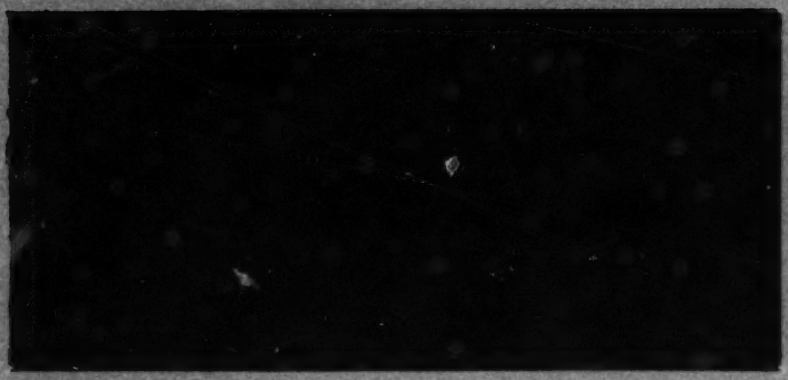
Polar Bear Studies in Eastern Lancaster Sound and Baffin Bay

Wildlife Service
Northwest Territories Renewable Resources



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Polar Bear Studies in Eastern Lancaster Sound and Baffin Bay

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1980

File Report No. 6

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ABSTRACT

Polar bear studies were done in April, May, 1978 and 1979 in Lancaster Sound and contiguous areas of Baffin Bay as part of Petro-Canada's environmental studies for E.A.M.E.S. Polar bears were captured with helicopters for standard mark-recapture techniques. Four female bears tagged with satellite monitored tracking radios in May 1979 are still being monitored (September). Polar bears were distributed in late winter along both coasts of Lancaster Sound. The south Devon Island coast and the north-south floe edge between Devon and Baffin Islands respectively, proved most productive for capturing bears. Reasons for a greater number of polar bears in the study area in 1979 than in 1978 are unknown, but returns from marked bears indicate that many came from points to the west and southwest which suggests that there was an influx or return to the study area in 1979. Summer retreats of polar bears included (1) the south and east coasts of Devon Island, particularly Radstock Bay, Maxwell Bay and Croker Bay; (2) the perimeter and coastal mountain areas of Bylot Island excluding the southeast corner; and (3) the west, north, and northeast coasts of Baffin Island. Little information is available on the autumn and early winter distribution of polar bears. We assume that they return to east Lancaster Sound as ice formation progresses and that their distribution at this time is similar to that of late winter. Marked polar bears captured close to shore tended to stay close to shore. This was supported by the four bears tagged with satellite monitored tracking radios. Bears marked in summer in the west Lancaster Sound area generally moved east. We speculate that they move back and forth as the ice recedes and forms, although some stay at nearby summer retreats when the ice melts. Bears of Lancaster Sound belong to the larger population of Prince Regent Inlet, Barrow Strait and Jones Sound. There also appears to be a connection between the bears of Lancaster Sound and those around Clyde River, although the eastern range limits remain undefined. Some marked bears were returned from Greenland. Family groups with newborn cubs were found along the south coast of Devon Island, particularly Radstock Bay and Croker Bay, and along the north sides of Brodeur Peninsula and Bylot Island. No large concentrations of dens or family groups were found, which indicates that denning habitat is widespread and abundant. We estimated that there were approximately 1,000 bears in Lancaster Sound in 1979 and 1,650 in Zone F. In Zone F, we estimated that 72 cubs were produced each year and 212 bears of all ages died. More information is needed to estimate productivity and mortality reliably. With the exception of a blowout, it is doubtful that drilling one exploratory well will have any impact on polar bears. This is not true of a major oil field development with its associated disturbance and man/bear conflicts. In the event of an oil spill and assuming the worst case of complete elimination of the polar bear population in Lancaster Sound, only a portion of the subpopulation will be affected and polar bears from the unaffected portion will repopulate. This assumes that the ecosystem returns to its pre-spill state and that hunting throughout F Zone is strictly curtailed to maintain breeding stock.

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INTRODUCTION

This paper describes the results of polar bear (Ursus maritimus Phipps) studies undertaken in Lancaster Sound and contiguous areas of Baffin Bay, as part of Petro-Canada's environmental studies. Petro-Canada proposes exploratory drilling at several widely spaced sites, north and south of, and including the mouth of Lancaster Sound. Consequently there exists the possibility of widespread oil pollution in Lancaster Sound and Baffin Bay should a blowout occur.

Petro-Canada's studies are part of the Eastern Arctic Marine Environmental Survey (E.A.M.E.S.) study, intended to provide "environmental clearance" for hydrocarbon development in nearshore and offshore areas between Jones Sound to the north and Cape Dyer on southeast Baffin Island. Resources however, were inadequate to cover the total E.A.M.E.S. area, so polar bear studies were confined to near the probable Petro-Canada well sites. It was agreed with Petro-Canada that those studies were preliminary and if needed, further studies would be funded when exploratory drilling proceeded.

Biology of Polar Bears

The distribution of the polar bear is circumpolar. Its Canadian range extends from the permanent pack ice of the Arctic Ocean and Arctic Islands to southern James Bay. At one time, it was believed that all polar bears belonged to a single population and individuals lived a nomadic existence

that covered the whole circumpolar region. However, recent mark-recapture programs have shown there may be as many as 15 relatively discrete subpopulations in Canada alone (Stirling et al. 1977).

Polar bears may be found throughout their range, but they spend most of their time, on a more or less regular basis, in certain key seasonal habitat areas. Of particular importance are feeding areas, breeding areas, denning areas, and summer retreats. All sex and age classes of a bear subpopulation may not use key habitats simultaneously. However, if some of these key habitats were eliminated it is likely that the subpopulation would decline. Maternity denning habitat is likely the most important habitat for bears.

Although any polar bear may dig a den and use it for a few days during a winter storm, probably only pregnant females den for an extended period, usually from about early November to late March or April. Harington (1968) and Van de Velde (quoted pers. comm. in Stirling et al. 1977) have reported instances of females denning with older cubs but to what extent this occurs is not known.

Polar bears are born in a maternity den between late November and January with differences in birth dates probably depending on latitudinal variation (Harington 1968). In the Lancaster Sound area, polar bears likely give birth in December or January. Denning females lose weight while suckling the cubs, as they do not eat during the denning period and live on stored fat (Harington 1968). At birth the cubs weigh approximately 0.7 kg, but by the time they leave the den in March or April, they weigh about 9 kg. After emerging, the family may remain near the den for several days before moving to the sea ice to hunt seals. Most polar bear cubs stay with their mothers until they are 2.5 years old, although some may remain into their 4th year. Their degree of maternal dependence, during this period, is not

precisely known. Lentfer (1976a) found the breeding cycle for females to average 4.13 years. The female breeds again when the cubs leave, usually in April and May, although due to delayed implantation, the fertilized egg does not begin to grow until September. Lentfer (1976) found that each female polar bear over 4 years of age produces an average of 0.407 young per year, indicating a low reproductive potential.

The polar bear preys mainly on ringed seals (Phoca hispida) and bearded seals (Erignathus barbatus), although its diet occasionally includes walrus (Odobenus rosmarus) (Harington 1970) and beluga whale (Dephinapterus leucas) (Heland and Hay 1976). Observations have been made of bears diving and coming up beneath seabirds to capture them, and diving for and eating kelp (Russell 1975). Polar bears capture seals by stalking them along leads, by waiting for them to surface at breathing holes (Stirling 1974), or by digging out pups and sometimes adults from the sub-nivean birth lairs. The distribution of polar bears depends upon types of ice (Stirling et al. 1975), but how the ice type influences polar bear distribution is not fully understood.

From freeze-up to break-up, ringed seals are segregated, with adults located in deep bays and sub-adults in unstable offshore ice (McLaren 1958). Consequently, polar bears hunt in areas of unstable ice where inexperienced sub-adult seals are their main prey. Stirling and McEwan (1975) found that over 80% of the ringed seals killed by bears during the spring, were 2 years old or less.

In April ringed seal pups are born in individual sub-nivean lairs on stable ice and to a lesser extent on unstable ice. Polar bears hunt on snow-drifted pressure ridges in offshore ice and dig out seal pups from those lairs (Stirling and Smith 1975). Seal pups are an easily accessible food

during the breeding period at a time when male polar bears lose considerable weight and when females are emerging from their dens with cubs of the year. The polar bear breeding and cub survival is probably directly related to ringed seal productivity.

Ringed seals begin hauling out onto the ice in May, and moult in June when they become lethargic and are reluctant to enter the water. Such accessible prey population probably allows bears to build up fat deposits for summer periods of minimal ice cover when seals are relatively inaccessible.

As the ice melts in summer, polar bears move with it or else come onto land at traditional summer retreats where they have been found denning in remnant snowbanks and loafing on shore. Polar bears at summer retreats are generally very fat and probably feed little, although Furnell and Oolooyuk (in press) saw them catch seals in open water. They may scavenge and feed on birds or vegetation depending on availability.

As ice forms in autumn, polar bears move off the land and begin to hunt seals again. The bears' pattern of seasonal distribution and movements is variable depending on the distribution and dispersal of the sea ice. As polar bears rarely eat all of a kill, scavenging of remains is probably important for the survival of sub-adult bears (Stirling and McEwan 1975). Little is known of polar bear autumn and winter feeding habits, although Harington (1968) reports that pregnant females without adequate fat reserves den later than others.

Polar bears are curious and usually investigate objects on the landscape. They may wander into settlements, either out of curiosity or in search of food, and have attacked and killed people in industrial camps (Schweinsburg and Stirling 1975). There is also one record of a female abandoning a maternity den when disturbed by large, mobile machines (Slaney 1974). In areas where they are hunted, polar bears run from the sound of snow machines.

Polar bears are carnivores at the top of the ecolgical food web, and so are probably susceptible to bio-accumulated marine contaminants. It is known that polar bears in Canada and Alaska have varying concentration of PCB's (polychlorinated biphenols) and heavy metals in their tissues (Lentfer 1976b, Bowes and Jonkel 1975), probably obtained through their food. As polar bears may be vulnerable to oilslicks when they swim, physical contact with oil could reduce the thermoregulatory role of their fur as well as causing irritation of mucous membranes, while actual ingestion could produce toxicosis. Little is known of the direct effects of hydrocarbon pollution on polar bears.

Polar Bears in the Lancaster Sound Area

Prior to 1975, information on polar bears in Lancaster Sound mainly resulted from Canadian Wildlife Service studies of polar bears in Barrow Strait and Lancaster Sound. These studies primarily were in western Lancaster Sound along the southwest coast of Devon Island (Stirling et al. 1977). In summer 1974, some preliminary surveys were carried out in Admiralty Inlet (Jonkel 1976). CWS flew brief reconnaissance surveys farther to the east along the south coast of Devon Island and the north coast of Baffin Island during the summer (Jonkel 1976).

Mark-recapture surveys described abundance, distribution, movements, population characteristics, and important polar bear habitats. CWS studies in Radstock Bay and Devon Island yielded information on hunting and intraspecific behaviour.

The amount of data gathered declines from west to east and few data were gathered past a line from the northeast tip of Somerset Island to Maxwell Bay on Devon Island. The substantial data from Radstock Bay and southwest Devon Island, compared to the rest of Lancaster Sound, are a reflection of the effort expended on the behavioral studies. Prior to 1975, one ground survey for dens was made on Bylot Island and some information was gathered from bears killed by hunters in Arctic Bay, Resolute Bay, and Pond Inlet.

During 1975, CWS expanded the Barrow Strait study into Prince Regent Inlet to learn more about local bears in relation to the proposed Arctic Islands Pipeline. Simultaneously, the N.W.T. Wildlife Service (NWTWS) conducted a study in Admiralty Inlet and south central Lancaster Sound related to the Nanisivik Mine development in Strathcona Sound. Additionally, the NWTWS, assisted by hunters from Pond Inlet, conducted a ground survey for dens on Bylot Island. In 1976, the NWTWS conducted a one season study in eastern Lancaster Sound related to the Norlands proposed hydrocarbon well (Schweinsburg et al. 1977).

Some progress was made toward delineating important habitats. Stirling et al. (1978) identified the southwest coast of Devon Island as a low density denning area compared to the denning concentration found in other areas, such as the Manitoba coast of Hudson Bay (Jonkel et al. 1972) or Wrangel Island (Uspenskii and Kistchinski 1972). The north coasts of Brodeur and Borden Peninsulas, and the west and northwest coasts of Bylot Island were identified as maternity denning areas. Jonkel (1976) reported that Borden Peninsula,

Brodeur Peninsula, and Bylot Island were also used as summer retreats by polar bears. Schweinsburg (1976) confirmed the observation and suggested that the sex and age classes of bears caught at summer retreats may differ from those caught on the ice in the spring, and that summer retreats may be important for the survival of young bears. Jonkel (1976) speculated that the entire southern coast of Devon Island was used by polar bears as a summer retreat. This is especially true of the deep landlocked bays that retain ice longer than Lancaster Sound; specifically Maxwell Bay, Croker Bay, and farther to the west, Radstock Bay. Stirling (1974) confirmed Radstock Bay and Maxwell Bay as summer retreats, but no comparable research was conducted along the southeastern end of Devon Island. Based upon bear observations and track counts, Jonkel (1976) indicated that polar bears concentrated along the floe edge at the mouths of Admiralty and Navy Board Inlets, at the mouth of Prince Regent Inlet, between Prince Leopold Island and southwest Devon Island, and along the south Devon Island coast.

Adequate capture information was available to define the distribution of bears in western Lancaster Sound in relation to habitat types and to draw some conclusions about polar bears' seasonal movements (Stirling et al. 1978). Schweinsburg et al. (1977) summarized the extent and results of previous polar bear studies in eastern Lancaster Sound. Their major conclusions were:

1. polar bears were distributed throughout Lancaster Sound, depending on ice conditions;

2. greatest concentrations of polar bears occurred along the north and south coasts of Lancaster Sound with possibly more along the north coast;

3. during work on the south side of Lancaster Sound, the highest spring concentrations were found immediately north of Bylot Island and across the mouth of Admiralty Inlet;

4. summer retreats were on Bylot Island, the north end of Borden Peninsula, the landfast ice of Croker Bay and probably Philpots and northwest Baffin Islands;

5. Lancaster Sound polar bears were probably of the same sub-populations as those of Barrow Strait, Byam Martin and Wellington channels, Admiralty Inlet and Jones Sound;

6. the mark-recapture data were sufficient to determine sub-population estimates, the fidelity of bears to certain areas, the movements and natality and mortality rates of bears in Lancaster Sound;

7. data on the southeast and east coasts of Devon Island and northeast Baffin Island were insufficient.

The above show that the data from preliminary studies were insufficient to determine the range of the subpopulation, seasonal movements, population dynamics, abundance, and distribution of polar bears in east Lancaster Sound. Nor was it known whether polar bears would contact spilled oil from a blowout by swimming through it or ingesting oiled seals or carrion. Until otherwise proven, we assumed that polar bears would contact spilled oil and that it would prove harmful. (Another study by E.A.M.E.S. is attempting to determine whether oil harms bears). The presence of shore-based logistics centres and the regular movements of supply ships and aircraft are potentially disruptive influences on wildlife in the area. Again, the effect of these activities on polar bears is unknown, but assumed harmful.

Objectives

The original terms of reference for the E.A.M.E.S. study called for information on: (1) population size,

(2) seasonal distribution,

(3) movements, and

(4) important areas (e.g. feeding, denning).

These objectives were later narrowed by the Department of Indian and Northern Affairs:

(1) to determine seasonal movements and distribution of bears in the areas, and

(2) to determine location, extent, and times of use of important habitats needed for the perpetuation of the species.

However, given the unknown but potentially serious effect of hydrocarbon exploration and spilled oil on all aspects of the polar bear's life history, we included secondary objectives, which would be determined at no additional cost, as follows:

(3) to determine the number and discreteness of the sub-populations of polar bears in the area,

(4) to determine the population estimates for each sub-population, and

(5) to determine the age structure, productivity, and mortality of each sub-population.

Additionally it should be noted that Canada has ratified the international "Agreement on the Conservation of Polar Bears" treaty. This article clearly relates to the terms of reference of the E.A.M.E.S. program. It states that "each Contracting Party shall take appropriate action to protect the ecosystems of which polar bears are a part, with special attention to habitat components such as denning and feeding sites and migration patterns, and shall manage polar bear populations in accordance with sound conservation practices based on the best available scientific data."

We feel that information is needed before development proceeds if we wish to mitigate or document impacts of the present project and develop a predictive capability for future hydrocarbon developments.

Of concern is the short-term nature of this study, funded to yield only enough information to assess the impact of exploratory drilling of one well in a comparatively small area. Future studies will be considered if and when drilling approval is granted. While this approach is understandable from industry's point of view, it produces a series of inadequate studies interrupted by periods of varying length to make political decisions. This is especially unfortunate in the context of E.A.M.E.S., which supposedly will give "environmental clearance" to large areas.

STUDY AREA

Petro-Canada's leases lie at the east end of Lancaster Sound and the adjoining waters of Baffin Bay. However, because of currents, weather patterns and the mobility of polar bears, Jones Sound, Lancaster Sound, Prince Regent Inlet, Admiralty Inlet, Navy Board Inlet, Pond Inlet, and associated islands and waters were also included in the study area (Fig. 1).

Physiography

Paleozoic basin sediments cover most of the area of eastern Somerset, Devon and extreme western Bylot Islands, as well as Brodeur and Borden Peninsulas. In the south, the basins consist of thin limestone and sandstone sediments (Paleozoic lowlands) which become thicker and form smooth plateaus

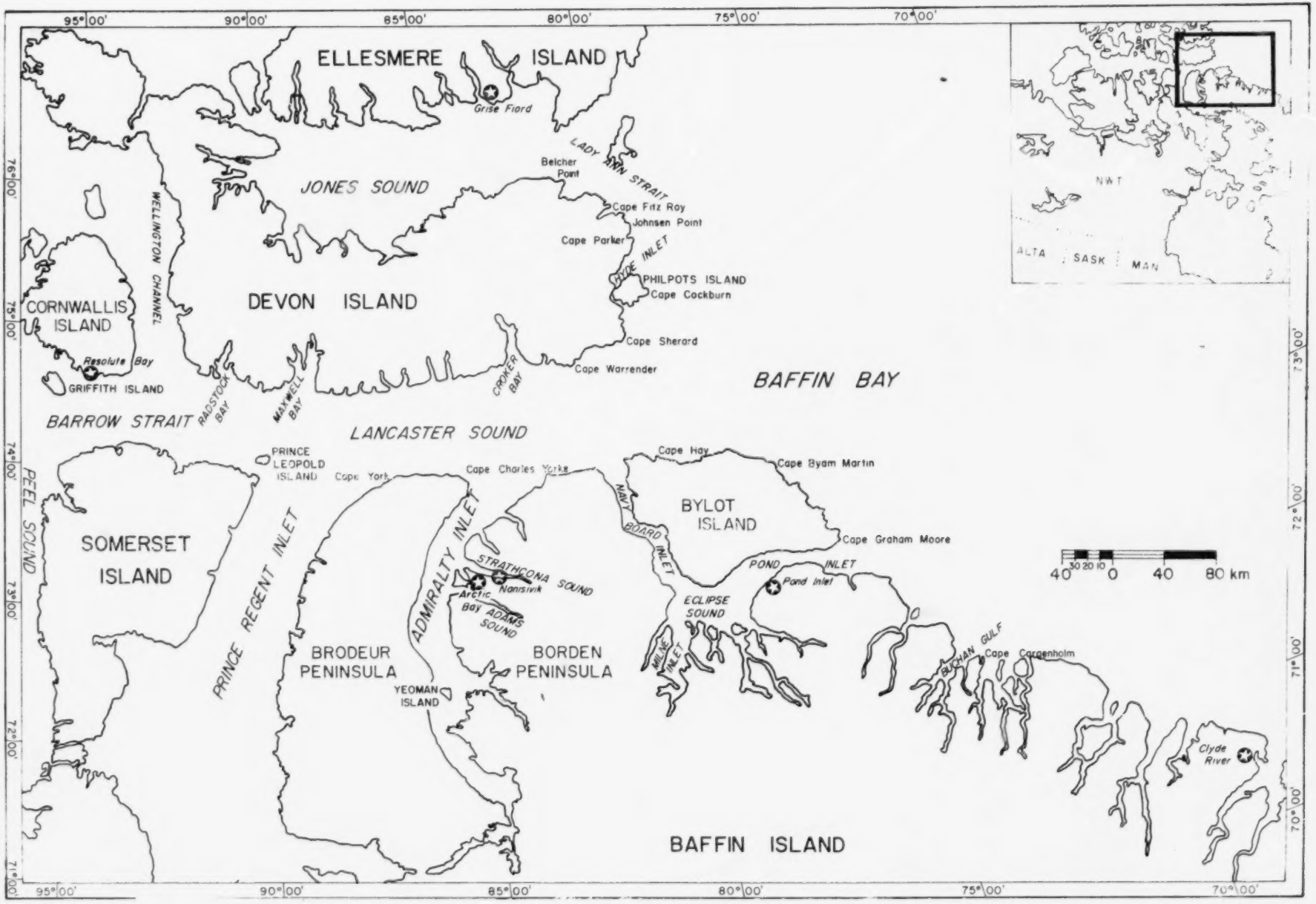

Fig. 1. Eastern Lancaster Sound (study area) and adjacent areas.

up to 600 m high (Paleozoic uplands) toward the north (Dunbar and Greenaway 1956).

Paleozoic sediments of the area are largely characterized by upland topography. Where these uplands are well developed and reach the coast along northern Somerset and southern Devon Islands, steep cliffs and talus slopes result. Drainage patterns are well defined, deep valleys have formed in the sedimentary rocks, and a few lakes are present.

The Precambrian Shield underlies much of the area and is conspicuously exposed in eastern Devon and Bylot Islands. The shield is composed of ancient metamorphic rocks. Although glaciated, these rocks have been exposed to little erosion in this area and form the high eastern edge of the Canadian Shield.

The south coast of Devon Island exhibits an ice-capped Precambrian highland east of Croker Bay and a flat-topped Paleozoic plateau west of Croker Bay. The highland is a northward continuation of the eastern mountains of Baffin and Bylot Islands and is covered in large part by a smooth and unbroken ice-cap, with heights up to 1890 m in the interior. West of the highland, crystalline rocks are overlain by flat-bedded Paleozoic limestone and other sediments, which form a dissected plateau. Part of the plateau is covered by a tongue of the Devon ice-cap, but much of the area westward which is at lower elevations has incomplete ice cover.

The northeastern portion of Somerset Island and northern portion of Brodeur Peninsula consist of a flat-topped plateau with a general elevation of 305 - 610 m that is dissected by deep, steep-sided river valleys and vertical cliffs along the coast.

In contrast to Brodeur Peninsula, Borden Peninsula is higher, rougher, and structurally more complex. Tilting and disturbance of the rock strata

have produced more uneven topography. Much of the northern part of the peninsula where elevations range from 610 - 1220 m is highly dissected. The terrain slopes off to a much lower north coast than that of Brodeur Peninsula, and the ice-caps are larger and more numerous. Between Strathcona and Adams Sounds, intrusive dykes form distinct northwest-southwest lines, some stretching across the peninsula beyond Milne Inlet. South of this zone where the rocks have been slightly tilted, lie a series of northfacing slopes.

Bylot Island is rugged, except for the southwest corner. Rising to more than 1830 m, most of the island is ice-covered and pierced by projecting peaks and ridges.

Surface Water Conditions

General Circulation

The depth of the channel from Lancaster Sound to M'Clure Strait ranges from 800 m at the eastern entrance to a 55 m sill in Barrow Strait and increasing again to 500 m in M'Clure Strait. From M'Clure Strait to Lancaster Sound and Baffin Bay, the main current flows east and the channels along the north side have a general southerly flow.

Lancaster Sound and its adjoining inlets and channels act as a transition between the waters of the Polar Basin farther to the west and waters to the east, which are formed by the mixing of Arctic and Greenland Current waters in Baffin Bay (Collin 1962, In Stepney 1977). Water from M'Clure Strait is obstructed by the Barrow Strait sill; consequently, only the surface layer passes eastward into Lancaster Sound.

The water in eastern Lancaster Sound is a mixture of Arctic Ocean water entering through Smith and Jones Sounds and the warmer, more saline water of the west Greenland Current (Collin 1962, Lalli et al. 1973, In Stepney 1977). This Current flows south along the east coast of Ellesmere Island and enters Lancaster Sound, flowing westward along the south coast of Devon Island before turning and again flowing eastward along the north coast of Baffin and Bylot Islands (Fig. 2). The Current is at least 10 km wide (Collin 1958, In Stepney 1977) and at times may occupy more than one-half the width of the Sound (Collin 1962, In Stepney 1977). Occasionally it extends northward along the eastern side of Wellington Channel.

General Ice Conditions

Descriptions of ice conditions are from Dunbar and Greenaway (1956) and Stirling et al. (1977).

The amount and duration of ice cover in Arctic waters increases generally from southeast to northwest. In the southeast, the Atlantic influence raises water temperatures, and cyclonic activity draws warm air from the south; in the northwest, the water is Arctic in origin, and the prevailing winds are north and west. Factors influencing local variation in ice conditions are surface area and depth of water, amount of tide and current, and orientation of channels and bays in relation to the prevailing wind.

Generally, ice formation begins in the sheltered inlets in late September, and in Lancaster Sound and Barrow Strait in October. In the Sound, the pack remains fairly open all winter with ice settling to the south. A narrow stretch of open water frequently runs the full length of the Devon Island coast. In some years an open patch of water, or polynia,

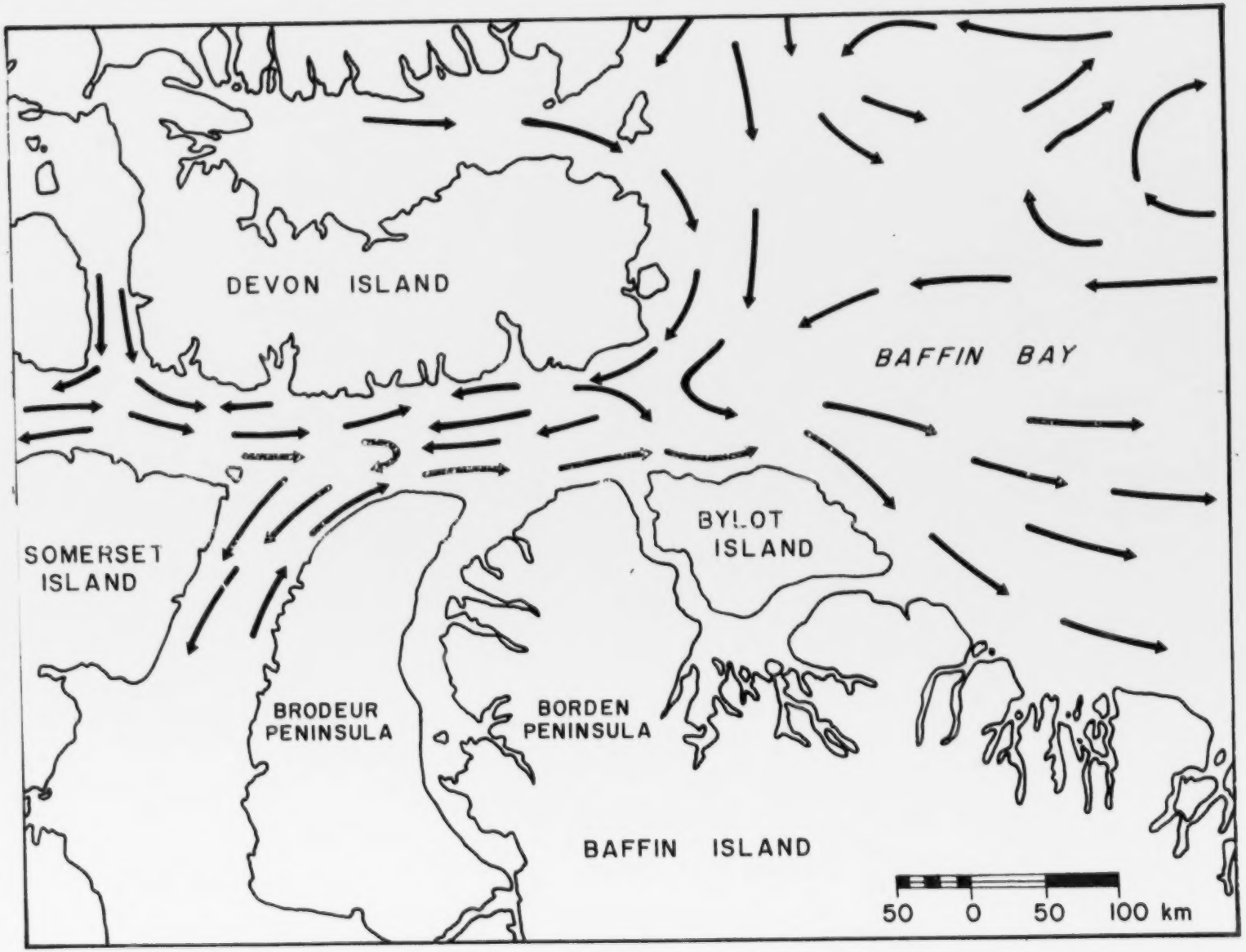

Fig. 2 Surface currents in the Lancaster Sound area. (taken from Davis and Sekerah, 1977)

extends from Griffith Island across Wellington Channel and Barrow Strait. Possibly influenced by northwesterly winds, the western side of Prince Regent Inlet is the last part to freeze over. The ice in much of this Inlet is unconsolidated for most of the winter, and a lead sometimes persists from the mouth westward along the northern coast of Somerset Island.

Admiralty, Navy Board, and Pond Inlets, as well as Eclipse Sound, usually freeze over entirely by November. Maximum ice thickness is reached in late April or early May. This thickness ranges from 1.5 to 2.5 m in the bays and inlets and slightly less in the channels, except where rafting and pressure-ridging have occurred.

Ice loosens in Lancaster Sound and Barrow Strait in June as the lead along the Devon Island coast increases toward the open water southeast of Cornwallis Island. Ice from Wellington Channel and Peel Sound moves into Barrow Strait and drifts eastward under wind and current action through Lancaster Sound. By mid-August, the Sound and most inlets at the north end of Baffin Island are ice-free, although ice remains somewhat longer in the deep bays (such as Maxwell and Croker Bay). Icebergs drift through Lancaster Sound during the summer.

Ice Conditions in 1978 and 1979

The preceding section describes the ice conditions in Lancaster Sound during what might be considered typical years. In both 1978 and 1979, spring breakup was delayed considerably and ice cover was heavier in comparison to typical years. Figure 3 is a simplified representation of ice conditions encountered during April, May 1978 and 1979. The floe edge in Lancaster Sound lay approximately 50 km further west during April, May, 1979 than at the same time in 1978. A more detailed description of ice conditions encountered during the study period follows in an area by area treatment.

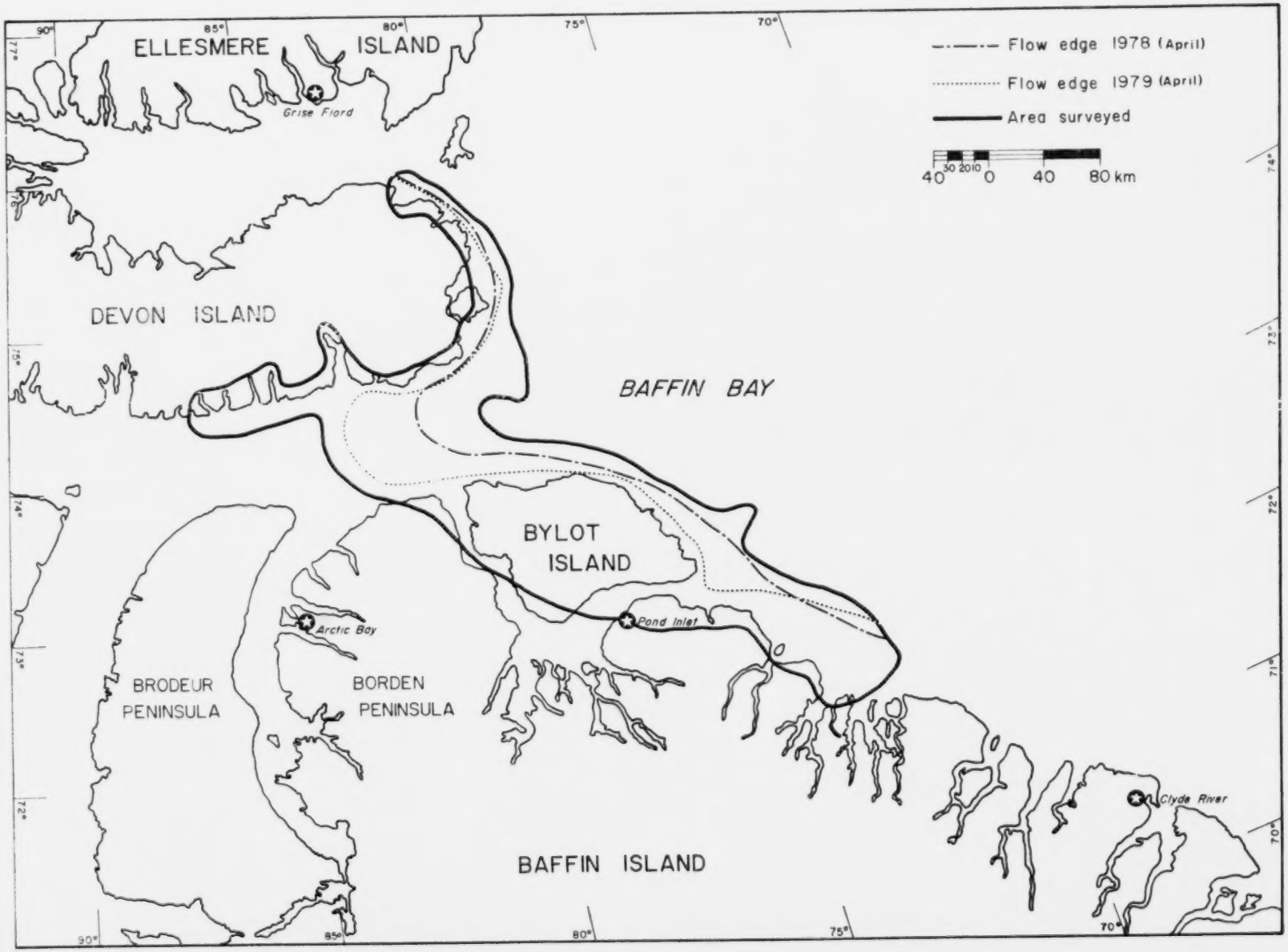

Fig. 3 Floe edge conditions and area surveyed in eastern Lancaster Sound during the 1978 and 1979 field seasons

South Devon Island

In 1979, the ice in the south Devon region was slightly roughened with scattered 1-2 m pressure ridges. Areas of heavier rough ice with 2-3 m pressure ridges and mounds occurred primarily in the mouths of major inlets and bays. Broad, flat areas were present beginning approximately 5 km offshore and continuing out into Lancaster Sound. The deep bays and inlets along the south Devon coast were covered with flat ice. Croker Bay ice was flat except for many small, frozen-in icebergs in the northern part.

These ice conditions were in contrast to 1978 when offshore ice along the south Devon coast was somewhat rougher (i.e. moderately rough, 3-5 m ridges). Also in contrast to 1978 was the lack of an old east-west oriented floe edge and the strip of very rough ice associated with this zone of ice shear.

East Devon Island

The ice conditions in this area were similar in 1978 and 1979. A strip of slightly to moderately rough landfast ice lay from Cape Warrender to Belcher Point. It varied considerably in width from as narrow as 0.5 km at Capes Sherard and Cockburn to 12 km in the area east of Cape Parker. In 1979, in contrast to 1978, this strip began breaking around 15 May. By 21 May the only ice cover along the entire east coast was in Hyde Inlet, the bay between Capes Sherard and Cockburn, and in the bays south of Cape Fitz Roy and Belcher Point.

East Devon Floe

In both years during April and May, Lady Anne Strait was entirely open as far south as Johnson Point. South of there, small and medium size floes surrounded by brash occurred adjacent to the landfast strip. This floe ice continued as far south as the Cape Sherard area beyond which lay open water.

Lancaster Sound

The majority of Lancaster Sound was covered with rough ice and scattered broad, flat areas during 1979. This was similar to the 1978 condition although pressure ice in 1979 was generally less rough. A band 3-5 km wide adjacent to the floe edge had newer, slightly roughened ice and less snow cover than the remainder of the Sound. The floe edge between Croker Bay and Cape Charles Yorke remained unchanged throughout the study period. However, an extensive cover of new gray ice which lay immediately east of the floe edge on 6 May was blown eastward 2 weeks later; from then on open water occurred across the entire mouth of Lancaster Sound and out into Baffin Bay.

North and Northeast Bylot Island

The landfast ice strip between Capes Graham Moore and Byam Martin was similar to 1978, varying from smooth to moderately rough and 2-10 km wide. During 1979, in contrast to 1978, the strip west of Cape Byam Martin was almost continuous rough ice as far as Cape Hay except for a flat zone 0.25 - 1 km wide paralleling the shore. Also in contrast to 1978 was the proximity of the floe edge to the shoreline between Capes Byam Martin and Hay. It lay

approximately 2 km offshore between these two points. The floe edge angled WNW into Lancaster Sound from the cliff 6 km west of Cape Hay.

Northeast Baffin Island

Ice conditions off NE Baffin Island during April and May 1979 were similar to 1978. A light to moderately rough landfast strip began widening near the mouth of Eclipse Sound attaining a maximum width of 30 km east of Buchan Gulf. This was approximately 10 km wider than at the same time in 1978. As in 1978, the southern portion off Buchan Gulf was largely flat ice grading to rougher ice further north. The floe edge off NE Baffin Island was less distinct than that in the Bylot Island region further north. In general, the westernmost floe area was represented by narrow cracks in newer flat ice and large floes surrounded by localized brash.

Northeast Baffin Floe

This area remained relatively unchanged during both field seasons until 4 May 1979 when it was last observed. The northern portion was mainly small to medium size floes surrounded by brash ice grading into large floes to the south off Buchan Gulf.

Climate

The following summary is taken from Dunbar and Greenaway (1956) and Meteorological Branch (1970). Representative climatic data are shown for

Resolute in Stirling et al. (1977). Winter in the Lancaster Sound region typically begins during late October as a stable area of high pressure builds up over the western part of the Arctic Islands and the MacKenzie Basin. Modifying effects caused by open water are reduced as ice and snow cover increases, and the area experiences a continental type of climate. Temperatures drop well below freezing and are lowest in February. The presence of cold, dry arctic air masses results in clear skies and little precipitation.

By March, temperatures begin to rise slowly with rapidly increasing day length, but warming is delayed by heat loss through reflection from ice and snow, melting ice and snow, and increased cloud cover. Precipitation increases with the moisture holding capacity of the air. By late May, temperatures begin to rise above freezing.

A series of weak depressions moves across the Arctic Islands throughout July and August, when more than one-third of the annual precipitation falls.

Decreasing day length in September results in large temperature differences between the rapidly cooling land masses and unfrozen water areas. Consequent intense cyclonic activity, strong winds, fog and low cloud are common during this time of year. Temperature gradients between land and water disappear by late October.

Winds

The surface winds of Lancaster Sound form a complex pattern. They are controlled by the dominant pressure system but are simultaneously influenced and directed by the steep shoreline topography (Collin 1962, In Stepney 1977). Winds from the northeast to southeast or northwest to southwest

generate strong east and west winds through the Sound. Onshore winds are deflected by coastlines in directions nearly parallel to the shore. In straits and inlets, the prevailing direction is usually along the channel, and windspeed increases as the channel narrows. Local winds may also result from formation of cold air over snow patches and glaciers, such as those found on Devon and Bylot Islands. This dense air drains seaward and increases in velocity where it overflows a precipitous coastline; at times this air extends several kilometers to sea.

Biology of Lancaster Sound

Phytoplankton and Zooplankton

Lancaster Sound is rich in nutrients from the large amount of deposited bird guano and glacial runoff (Sekerak et al. 1976) and from current upwelling (Nettleship 1977). Those high levels of nutrients are the basis of a relatively high level of primary productivity, (Milne and Smiley 1978).

In Lancaster Sound, phytoplankton are restricted to the surface Arctic layer because of their dependence on light. Although diversity was low in comparison to lower latitudes, Sekerak et al. (1976) found 125 species of phytoplanktons (predominantly diatoms) in Lancaster Sound.

In spring, a characteristic feature of Arctic and Lancaster Sound phytoplankton is the presence of diatoms adapted to low intensity subsurface illumination. They grow on the underside of the ice and bloom at the ice/water interface. Their populations decline in early summer and are replaced by open water flora composed primarily of centric diatoms.

During late summer, boreal species of phytoplankton increase in Lancaster Sound as do dinoflagellates. Dinoflagellates may play an important

secondary role in the arctic food chain - although the specific links are unknown. Sekerak et al. (1976) found that phytoplankton were most abundant at depths of 4 and 30 m. Characteristically, phytoplankton standing stock dropped in Lancaster Sound at the end of the summer - probably because of a combination of factors such as nutrient depletion and diminishing light intensity.

Zooplankton occurring in Lancaster Sound are characteristic of the surface and middle Arctic layers (Sekerak et al. 1976), and relatively few species accounted for the majority of zooplankton taken. Copepods of nine species were dominant - although pteropods, ctenophores, amphipods, chaetognaths, and larvaceans were also present.

Benthic Organisms

The marine benthic community of the study area consists primarily of four invertebrate groups: Molluscs, Enchinodermas, Crustaceans, and Polychaetes (Slaney 1974). The benthic community provides food for demersal fish, seabirds, marine mammals, and predatory benthic organisms.

Fish

Fishes are few in species and number and are mainly benthic. A few species, such as the Arctic Cod (Boreogadus saida) and the anadromous Arctic Char (Salvelinus alpinus) are pelagic and feed largely on plankton. However, most are demersal, such as cottids that live and feed near the sea bed or bathypelagics that live and feed in mid-water (Slaney 1974).

Marine Mammals

Marine mammals prey upon benthic organisms, zooplankton, and fish. Four whale species occur in Lancaster Sound: narwhal (Monodon monoceros), beluga, bowhead whale (Balaena mysticetus) and killer whale (Orcinus orca) although the last two are not common. Pinnepeds include ringed seals, bearded seals, harp seals (Phoca groenlandica) and hooded seals (Cystophora cristata). The carnivorous species that feed largely on marine mammals are the polar bear and the Arctic fox (Alopex lagopus). The Arctic fox also feeds seasonally on birds and lemmings.

Birds

Lancaster Sound and contiguous water and land areas contain large numbers (probably millions) of migrating, staging, moulting, and breeding birds. The most abundant species are Northern Fulmar (Fulmarus glacialis), Glaucous Gull (Larus hyperboreus), Black Guillemot (Cepphus grylle), Black-legged Kittiwake (Rissa tridactyla), Arctic Tern (Sterna paradisaea), Thick-billed Murre (Uria lomvia), Dovekie (Alle alle), Common Eider (Somateria mollissima), King Eider (Somateria spectabilis), Oldsquaw (Clangula hyemalis) and Greater Snow Goose (Chen caerulescens atlantica). Rare species include Ivory Gull (Pagophila eburnea), Peregrine Falcon (Falco peregrinus), Gyrfalcon (Falco rusticolis). Those birds either directly or indirectly obtain most of their food from marine food chains.

Terrestrial Mammals

Terrestrial mammal species of nearby land areas include ermine (Mustela erminea), brown lemming (Lemmus sibiricus), collared lemming (Dicrostonyx torquatus), arctic hare (Lepus arcticus), caribou (Rangifer tarandus), muskoxen (Ovibos moschatus), wolf (Canis lupus), and wolverine (Gulo gulo). These mammals feed on other terrestrial mammals, vegetation, fish, birds, or on carrion scavenged along the beaches.

Vegetation

Phytogeographically, the vascular flora of the area fall within the Arctic Archipelago Province (Porsild 1955). Although comparatively poor in number of species, the relatively high number of endemics implies that part of the area may not have been glaciated.

Generally, the community structure of the Arctic vegetation is simple and of low density: i.e. few species with much unoccupied ground between individuals. All plant species are low-growing.

Vegetation is largely confined to runoff areas from snowdrifts or to depressions where moisture accumulates. Mountain avens (Dryas spp.), willows (Salix spp.), sedges (Carex spp.), mosses and lichens are characteristic of moist, densely vegetated areas. Open, drier areas tend to be colonized by wood rushes (Carex spp.), mountain avens and purple saxifrage (Saxifrage spp.).

METHODS

Sources of Data

Data in this report originated from studies done specifically for Petro-Canada through E.A.M.E.S. during 1978 and 1979. Considered with this information were data taken from Stirling et al. (1978) for west Lancaster Sound and Barrow Strait and Schweinsburg et al. (1977) for east and south Lancaster Sound. Hunter kill data were obtained from the Hunters' and Trappers' Associations of the respective settlements through the NWTWS hunter kill return program.

Field Techniques

The two possible approaches in a study of this nature are direct or indirect counting. Each approach has its biases and problems. We chose the indirect method of mark-recapture for the following reasons: (1) more information is obtained per dollar spent, (2) results can be compared with other nearby ongoing studies of the CWS and NWTWS, and (3) it is difficult to systematically count a sparsely distributed, white animal in the variety of ice and snow conditions found in the study area.

We used a helicopter to find and capture polar bears, as described by Lentfer (1968) and Larsen (1971). Searches were conducted in April and May in 1978 and 1979 (Table 1). Search effort was concentrated over ice habitats such as floe edges and areas of drifted pressure ridges which had proved productive in past studies; areas of high track density were given particular

Table 1. Summary of search effort in April and May 1978 - 1979.

	No. of days (1978)	No. of days (1979)
South Devon Island	7	8
East Devon Island	2.5	6
East Devon floe ice	.5	-
Lancaster Sound	1.5	3
North and northeast Bylot Island	4.0	6
North and Northeast Bylot floe ice	.75	-
Northeast Baffin Island	3.75	5
Northeast Baffin floe ice	-	-
Total	20 days	28 days

attention. The majority of polar bears were located by visual scanning, although when snow conditions were favorable, tracking was used to find bears. Little time was spent over the floe ice because of hazardous ice conditions. Mid-Lancaster Sound received more attention in 1979 than in 1978 because of the continued polar bear capture success along the floe edge in that region.

Polar bears were immobilized with Sernylan (phencyclidine hydrochloride Parke, Davis and Co.); the dosage approximated 100 mg/45 kg body weight. Some bears received the tranquilizer Sparine (promazine hydrochloride, Wyeth Laboratories Inc.) in varying dosages. Once polar bears were immobilized, they were marked with individually numbered polyurethane ear tags (Western Industrial Research and Training Center, Edmonton, Alberta). Bears were also tattooed on both sides of their upper lip with a number corresponding to the ear tag numbers. Data recorded for each bear included weight, sex, total length, thoracic girth, physical condition and any abnormalities. The first premolar was pulled for age determination. All bears were painted with a number using Lady Clairol hair dye for subsequent identification from the air. Short and long-term movements as well as population limits were determined through the resightings of painted bears, recapturing of marked individuals, and by returns of marked bears killed by hunters.

Recording of Tracks

Tracks were useful in determining concentration areas and distribution of bears. During April and May, tracks of females with cubs of the year helped locate maternity denning areas.

Denning Information and Surveys

When helicopters were used for capture-recapture studies, most sightings of tracks or females with cubs of the year were recorded to delineate coastal regions that might be important for maternity denning. In most instances, tracks of females with cubs of the year leaving the land or seen in coastal areas were recorded.

Schweinsburg et al. (1977) used helicopters specifically to search for dens, family groups, or tracks of family groups along the north coast of Brodeur Peninsula and Bylot Island. This survey was hampered by poor tracking conditions. No ground surveys for dens were conducted specifically for the E.A.M.E.S. studies. Previous ground searches for denning areas (Schweinsburg et al. 1977) were conducted by Inuit hunters and personnel of the NWTWS, who used motorized toboggans (Table 2).

Specimen Collection from Inuit Hunters

Hunters were paid for returned tags, lip tattoos and the lower jaws of killed bears.

Hunting Patterns

To determine whether the ratio of male to female bears killed by hunters from the different F Zone settlements (Fig. 4) varied seasonally, a Chi-square analysis was applied to the spring and autumn kill of each settlement. To determine if the sex composition varied seasonally within settlements, a Chi-square analysis was used.

Table 2. Dates and locations of ground surveys conducted for polar bear maternity denning areas in the Lancaster Sound area (from Schweinsburg et al. 1977).

Dates	Locations	References*
1973	East coast of Bylot Island	Ransom, S. 1973. A report of denning survey Pond Inlet, N.W.T. N.W.T. Fish and Wildlife Service. Unpublished Work Report.
1 - 8 April,	Bylot Island - South Eclipse Sound	Sangoyak, J. and Katsak. 1975. Hawkins, R. ed. Denning survey 1975 Pond Inlet, N.W.T. N.W.T. Fish and Wildlife Service. Unpublished Work Report.
6 - 14 April,	Bylot Island	Sangoyak, J. and Mokyak. 1976. Hawkins. R. ed. Bylot Island Polar bear denning survey. N.W.T. Fish and Wildlife Service. Unpublished Work Report.
6 - 15 April, 1976	Pond Inlet to Cape Cargenholm, Baffin Island	Hawkins, R. 1976. Polar bear denning survey Pond Inlet to Cape Cargenholm. N.W.T. Fish and Wildife Service. Unpublished Work Report.

* Internal work reports not available for distribution.

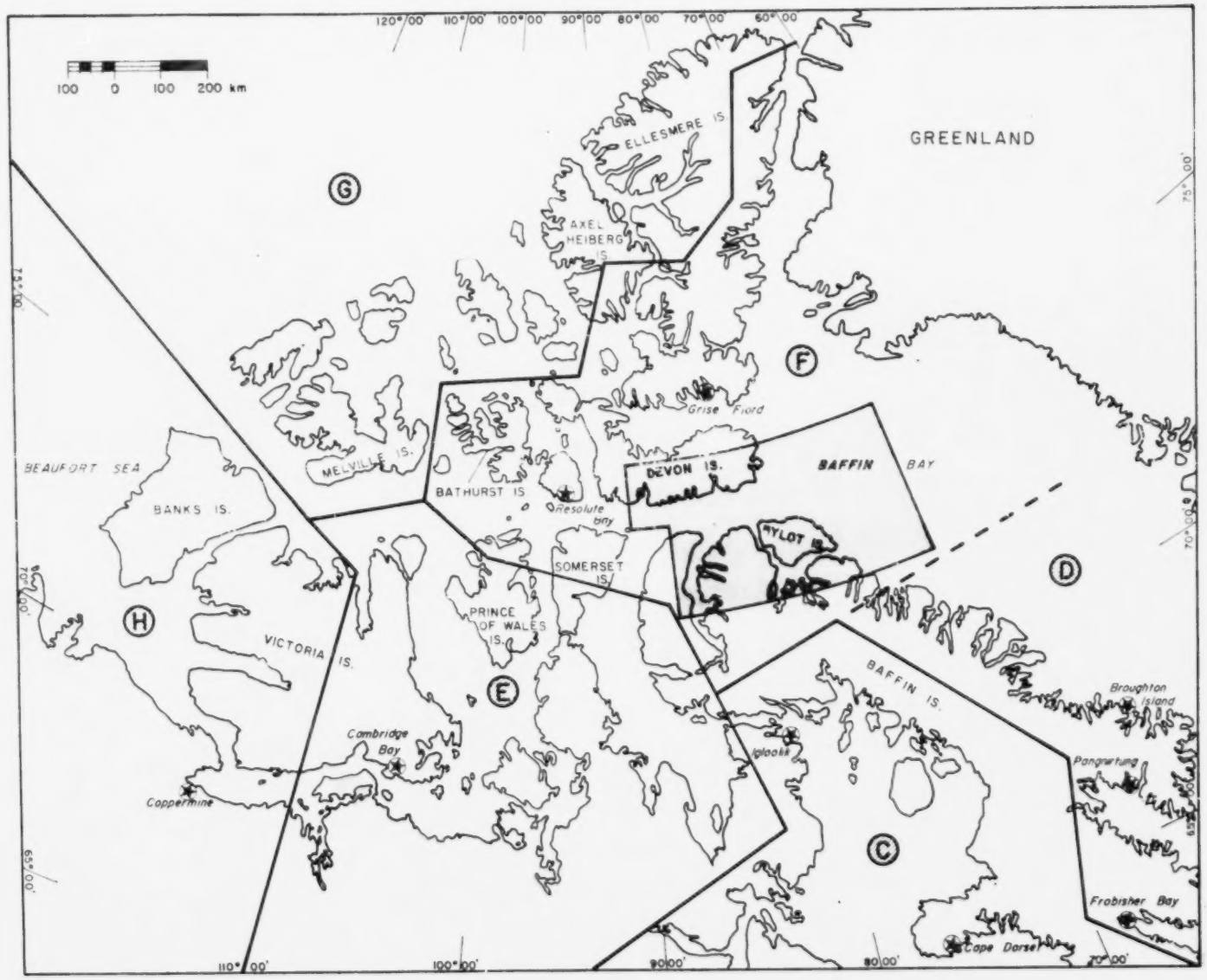

Fig. 4 The Federal-Provincial Polar Bear Technical Research and Management Committee's F Zone and adjacent zones. The study area is shaded.

Satellite Monitored Tracking Radios

In April and May, four female polar bears in Lancaster Sound were equipped with harnesses carrying radio transmitters capable of being monitored by Nimbus satellite through NASA. Two of the females were accompanied by cubs of the year and two were lone females. The movements of those bears are currently being monitored.

Laboratory Techniques

Ages of bears were determined by counting the annual growth rings in the decalcified and stained cementum of teeth collected from captured or hunter-killed bears. The histological methods of Thomas and Bandy (1973) were modified according to Stirling et al. (1977).

Data Analysis

Source

Data collected during the spring of 1978 and 1979 in the eastern Lancaster Sound area were analysed to obtain estimates of population size, age distribution, productivity, movements and distribution. The population estimate for eastern Lancaster Sound was calculated from capture-recapture data from the area shown in Figure 4 over the years 1970 - 1979. For comparison, and to reassess polar bear population characteristics and size in F Zone, the capture-recapture information from (1) Stirling et al. (1978),

(2) this report, and (3) that collected jointly by C.W.S., N.W.T.W.S. and United States Fish and Wildlife Service (U.S.F.W.S.) on southwest Devon Island during the summer of 1978 were combined.

Population Estimate

Population estimates, based on mark-recapture data, were calculated using a modified Peterson method (DeMaster et al. 1980). This technique was used because insufficient samples were available to provide accurate population estimates by the Jolly-Seber method.

The modified Peterson technique assumes that:

1) the annual survival rate (Ø) and its variance (var Ø) are constant throughout the sampling period, and are the same for marked and unmarked polar bears;
2) all animals have an equal probability of being captured;
3) animals do not lose their marks and all marks are reported when recovered;
4) all samples are instantaneous; and
5) all polar bears caught in the ith sample have the same probability of being returned to the population.

To address these assumptions, the following conditions are presented. The survival rate (Ø) used in the population estimate calculations was derived from the age distribution using an exponential curve fitted by a log linear regression. An error variance of 0.00375 was used as calculated by DeMaster et al. (1980) when considering a range of survival rates from 0.76 to 1.0.

The use of helicopters reduced problems of unequal catchability because few bears were able to escape once spotted. In the infrequent cases when ear tags were lost, the lip tattoo usually provided identification of individuals. In a few cases bears could not be identified. Only recaptures, not hunter returns, were used in calculating population estimates; therefore all marks can be assumed reported. Although sampling was not instantaneous, unique marks prevented double counting of animals, thus eliminating the bias that prolonged sampling introduces. Deaths from capturing were not a problem with the field techniques employed and it is assumed animals had a 100% probability of returning to the population.

N_i (Population estimate at time i was calculated as follows:

$N_i = M_i/P_i$ where: M_i = the number of tagged animals available for sampling just prior to the ith sample;

$M_i = \emptyset\ (R_{i-1} - m_{i-1} + M_{i-1})$

P_i = the proportion of marked animals in the population;
$= m_i/n_i$

n_i = the total number of animals captured in the ith sample;

R_i = the total number of marked animals, including recaptures, shown in the ith sample;

m_i = the total number of previously marked animals captured in the ith sample;

$\emptyset$ = survival rate.

The variances of the estimates M_i and N_i were calculated after DeMaster et al. (1980) as follows:

$$\text{Var } (M_i) = (R_{i-1} - m_{i-1} + M_{i-1})\ \phi\ (1-\phi) + \phi^2 \text{ var } (M_{i-1})$$

$$+ (R_{i-1} - m_{i-1} + M_{i-1})^2 \text{ var } \phi + 2\ (R_{i-2} - m_{i-2} + M_{i-2}) \text{ var } \phi$$

$$\text{Var } (N_i) = \text{var } (M_i)/P_i^2 + \text{var } (P_i)\ (M_i^2/P_i^4)$$

where: var $P_i = P_i\ (1-P_i)/n_i - 1$ and Var $\phi = .0037$.

Age Structure

Age structure samples originated from four sources: male kill, female kill, male capture and female capture. Before fitting a curve to the age distribution data, the samples were compared in 2 X C contingency tables to determine if any could be pooled. Bears older than 8 years were grouped into five categories (9-10, 11-12, 13-14, 15-19, 20+) to yield sufficiently high expected frequencies for contingency testing. Any comparisons involving kill samples did not include cubs of the year (Coy) or yearlings as NWTWS regulations select against younger animals. The age structure for eastern Lancaster Sound was based only on the capture sample from 1978 and 1979, as the kill sample was too small and incomplete for valid comparisons.

The kill and capture samples from F Zone were shown not to be independent of source; consequently only the captive sample was used to calculate mortality. An exponential curve was fitted by a log-linear regression to the capture data from ages 0 to 25. The use of an exponential curve assumes a constant mortality rate, which may not accurately reflect the mortality of the first four age classes. Using the curve, the sample was then expanded to equal a sample as large as the estimated populations of Zone F. The expanded regression was used to predict age class frequencies and estimate age-specific cub production. Exponential curves were also fitted to

the unpooled kill data from 2 - 25 years for the calculation of mortality.

Productivity

Productivity was estimated using observations of family groups made during capture operations. For productivity determination, age classes greater than 10 years were divided into three groups (11-14, 15-18, and 19-24) and age-specific litter size, age-specific probability of parturition, and age-specific natality rates were calculated after Stirling et al. (1977).

Age-Specific Probability of Parturition

Age-specific probability of parturition was calculated as follows:

$$\frac{\text{Number of X females with Coy} + \text{Number of X+1 females with yearlings}}{\text{Number of X females} + \text{Number of X+1 females}}$$

Where X is the age class for which calculations are being made. The number of X + 2 year old females accompanied by cubs 2 years old was not included because family groups normally disperse during the cubs' 3rd year. Therefore females captured soon after their 2 year-old cubs had left would negatively bias the statistic. Negative bias would also occur if complete litters were lost any time between birth and 2 years of age.

Age-Specific Litter Size

Age-Specific litter size was calculated as follows:

$$\frac{\text{Number of Coy with X females + Number of Yearlings with X + 1 females + Number of 2 year-olds with X + 2 females.}}{\text{Number of X females with Coy + Number of X + 1 females with yearlings + Number of X + 2 females with 2 year-olds.}}$$

Where X is the age class being considered. In calculating litter size, 2 year-old cubs were included because only observations of family groups, not lone females, were used. Partial loss of a litter would negatively bias this statistic.

Age-Specific Natality Rate

Age-specific natality rate in units of cubs/females/year was calculated as follows:

m_x = (Age-specific probability of parturition) (Age-specific litter size).

A weighted mean natality rate (m_x) was also calculated using a weighted mean litter size and a weighted mean probability of parturition. The last two statistics were calculated incorporating the survival rate to adjust for the number of females and cubs surviving from year to year.

By substituting in the formula given by Bunnell and Tait (1978) for natality (Litter size ÷ by Breeding Interval), a breeding interval was calculated.

RESULTS AND DISCUSSIONS

Distribution

Late Winter

In April and May of 1978 and 1979, 230 bears were captured in the eastern Lancaster Sound area (Fig. 5). Of those, 39 were recaptures from this or previous studies and 56 were resighted at least once. During the 1977/78 and 1978/79 seasons, Inuit hunters from Grise Fiord, Pond Inlet, Arctic Bay, Resolute Bay and Clyde River returned tags from a total of 32 bears, tagged in this or previous studies. Many of the recaptured bears had originally been captured outside the study area. Distribution of bears captured and recaptured in Lancaster Sound prior to 1978 is given in Stirling et al. (1978) and Schweinsburg et al. (1977).

More bears were encountered in 1979 than in 1978. In 1978, 8,994 km in 96 hours were flown in search of bears, and 7600 km in 146 hours in 1979. Each bear requires a certain amount of helicopter time during the immobilization process and the fewer search kilometres in 1979 reflects the larger number of bears encountered.

Search productivity was measured by km flown/bear captured (Table 3). In both years, the south Devon coast was the most productive area. Most captures were on the rough ice within 7 km of the coast and in the mouths of major inlets and bays. Flights were confined mainly to within 10 km off-shore as the area further out in Lancaster Sound generally proved unproductive.

The mid-Lancaster Sound region in 1979 proved to be nearly as productive as the south Devon area. Although only 3 survey days were spent compared to 8 days in south Devon, productivity was 34 km/bear captured. Almost all bears were found within 2 km of the floe edge.

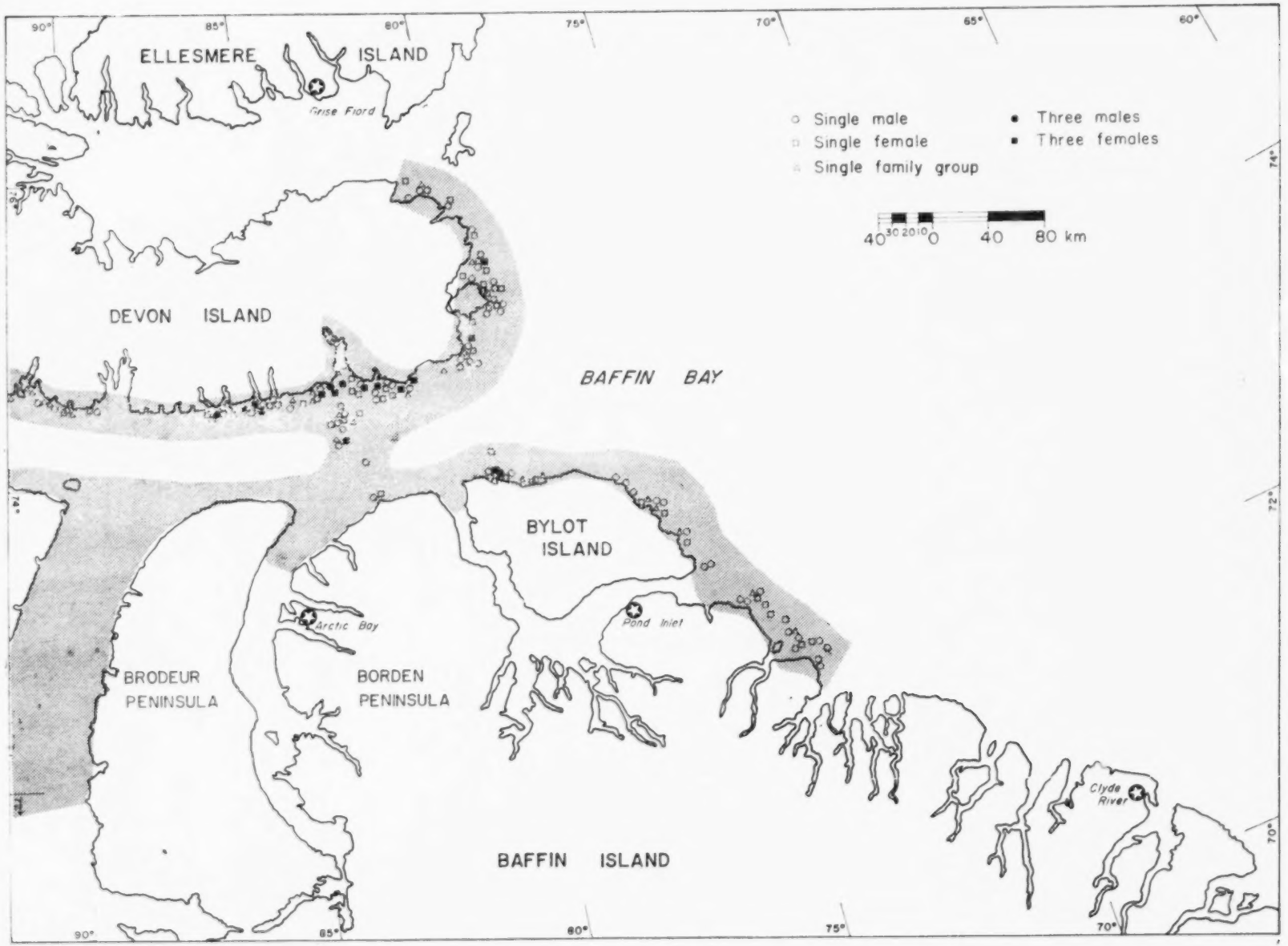

Fig. 5 Capture locations of polar bears from this study and spring concentration regions from this and previous studies (Milne and Smiley, 1977).

Table 3. Summary of capture success by area in 1978 and 1979.

	1978		1979	
	Km flown	Km/bear captured	Km flown	Km/bear captured
South Devon Island	3161 km	109 km/bear	2565 km	33 km/bear
East Devon Island	2256 km	376 km/bear	1910 km	48 km/bear
East Devon floe edge	110 km	no bears	-	
Mid-Lancaster Sound	515 km	515 km/bear	546 km	34 km/bear
North and northeast Bylot Island	1582 km	113 km/bear	1344 km	56 km/bear
North andnortheast Bylot floe ice	250 km	no bears	17 km	no bears
Northeast Baffin Island	1120 km	280 km/bear	1217 km	64 km/bear
Northeast Baffin floe ice	-		-	
Total	8994 km		7599 km	

The east Devon region also had more bears in 1979 than in 1978. Captures were primarily in the Capes Sherard and Cockburn areas, and in a system of refrozen leads in the mouth of Hyde Inlet. Seventy-three percent of bears in this area were found on roughened, fast ice habitat and 27% were at the floe edge.

In 1978 and 1979, the south half of the study area provided fewer bear captures on a rate basis than did the northern half. During fixed-wing aerial surveys in 1976, Johnson et al. (1976) and Stepney (pers comm.) also found this to be the case. Capture locations were scattered along the entire landfast ice strip, with 67% of bears found on landfast ice and 33% at the floe edge. There had been local concentrations of bears immediately north of Cape Hay in 1978 but this did not occur in 1979 when ice conditions were quite different. In 1979, the floe edge touched shore, and for 2-3 km north of the Cape new gray ice was followed by broken floe ice.

In the northeast Baffin region 64 km were flown per bear captured. This was the lowest capture rate within the study area. As in the Devon Island area, bears appeared to favor roughened, landfast ice over floe edge with 68% found on landfast ice and 32% at floe edge. In both 1978 and 1979, the wide, flat ice east of Buchan Gulf was unproductive.

Polar bears tend to follow floe edges along landfast ice and therefore one would expect them to be distributed along the north and south coasts of Lancaster Sound. The unstable ice associated with floe edges is a favoured habitat in which polar bears hunt and catch seals. In the Beaufort Sea, Stirling et al. (1975) found that polar bears were most frequently sighted in active ice zones and along floe edges. No bears were captured out on the floe ice of Baffin Bay because of limitations of finding and capturing bears by helicopters on floe ice. Numerous tracks crossed the floe edge however,

and there is no doubt that bears use Baffin Bay. The fixed-wing surveys conducted by Petro-Canada's consultants should determine how important the offshore ice is to polar bears.

Polar bears rarely use the flat landlocked ice of deep bays in winter. Although the highest densities of seals are found in such places, it is possible that seals are less vulnerable to predation in such unbroken ice conditions. Exceptions were female bears with newborn cubs, which empirically, seemed to prefer inshore areas and deep bays when they first emerged from denning.

An obvious difference in the 2 years of this study was the greater number of polar bears encountered in the study area in 1979. Reasons for the dramatic increase in 1979 are unclear. Ice conditions in 1979 were not significantly different from those in 1978. In both years, ice breakup in Lancaster Sound was late. The main differences between years were: (1) the floe edge lay some 50 km further west in 1978; (2) Lancaster Sound and the south Devon Island area had less rough pressure ice in 1979; and (3) the landfast ice off east Devon Island broke up earlier in 1979.

The recapture information may provide a clue as to where the bears came from in 1979. Many recaptures were bears captured several years ago at points to the west and southwest of the area surveyed in 1978 and 1979. There may have been an influx of bears into the study area from the west and southwest. Furthermore, a local influx of bears was detected in 1979 along the mid-Lancaster Sound floe edge between 19 May and 23 May 1979. Prior to this period, search flights along the floe edge had proven unproductive, but beginning on 19 May many more bears were encountered there. Possibly these bears represented an onshore movement from Baffin Bay. Only future work in eastern Lancaster Sound will determine whether 1978 and 1979 represent

extremes in polar bear density or if in fact, one year was more "typical" than the other.

Summer

No bears were captured during the summers of 1978-79 in the eastern Lancaster Sound area. Summer distribution for previous years is reported in Schweinsburg et al. (1977), Johnson et al. (1976) and Stirling et al. (1978). As the ice melts, some polar bears move to deep bays with landlocked ice, and later to land areas. Stirling et al. (1978) reported a general northerly movement from late winter to summer, which may suggest that some bears move north with the ice as summer proceeds. Johnson et al. (1976) found bears on offshore pan ice during August and September. During studies of summer retreats along the south coast of Lancaster Sound, Schweinsburg (1976) found polar bears swimming offshore and tracks leading from land to water. Furnell and Oolooyuk (in press) observed polar bears catching seals in open water during the summer. This is contrary to previous theory (Stirling et al. 1978), but how often it occurs, and its importance to the survival of bears at summer retreats is unknown.

Summer retreat areas for polar bears within the study area included (1) the south and east coasts of Devon Island, particularly Radstock Bay, Maxwell Bay and Croker Bay; (2) the perimeter and coastal mountain areas of Bylot Island excluding the southeast corner; and (3) the west, north, and northeast coasts of Baffin Island (Fig. 6). At summer retreats, bears or tracks were seen as far inland as 56 km and at elevations to 915 m. Denning of bears at summer retreats is reported in Schweinsburg (1979).

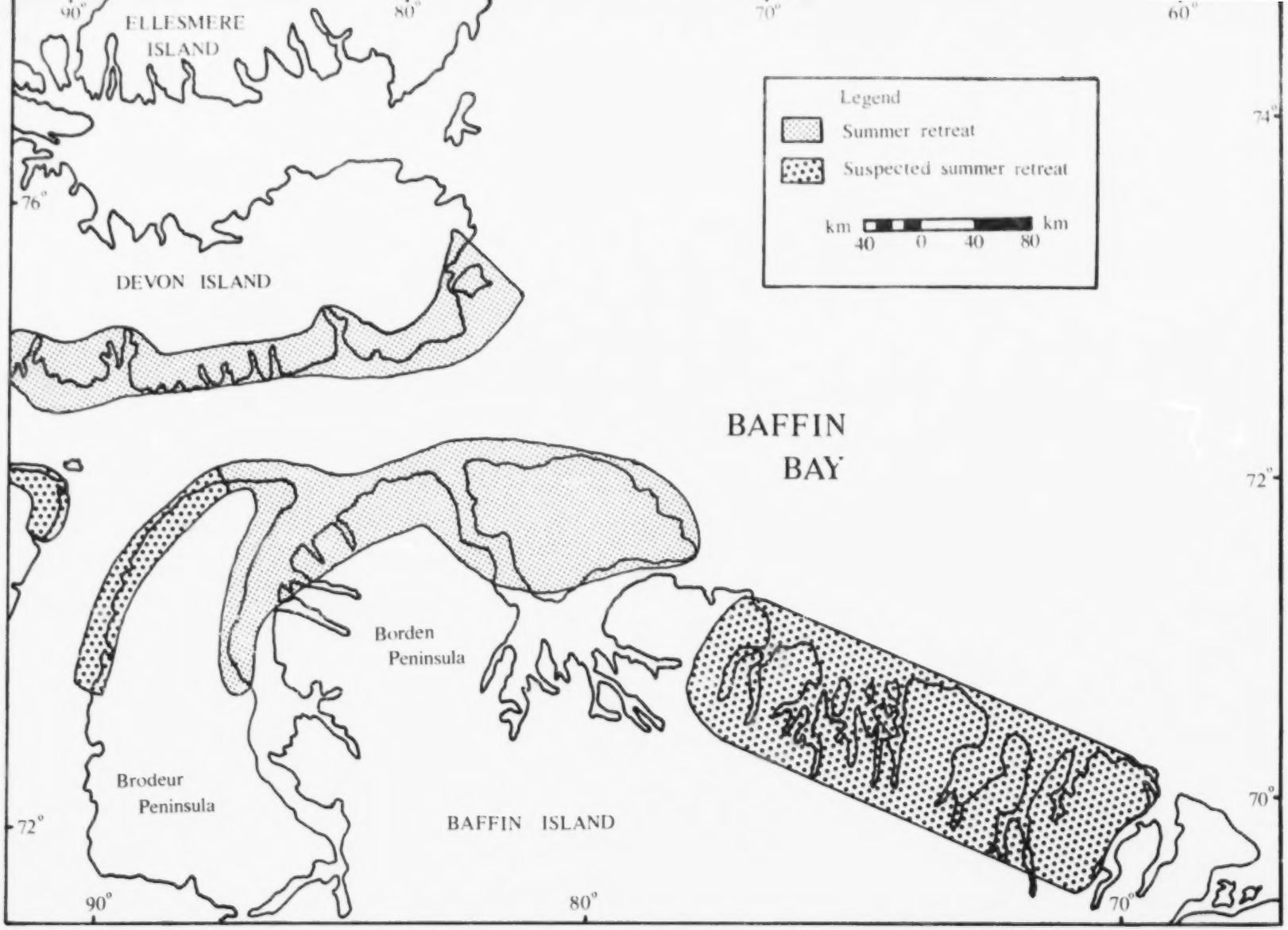

Figure 6. Summer distribution of polar bear in the Lancaster Sound area

The proportion of bears that go to summer retreats on land probably depends on local ice conditions. In southern Hudson Bay, where all ice disappears, summer retreats are obligatory for all sex and age classes of polar bears. Farther north, where summer ice conditions are more variable, summer retreats may not be used to the same extent. In Lancaster Sound, there is evidence that some bears come onto land or move to areas of permanent ice whereas others drift on floating ice pans in the summer (Schweinsburg 1976, Johnson et al. 1976, Stepney pers. comm.).

Schweinsburg et al. (1977) compared the number of young male and female bears (3 - 4 years) to adult male and female bears (5+ years) in samples captured during spring and summer. Bears 1 to 2 years old were not included as they do not move independently of their mothers. There was a significant difference ($X^2 = 4.2625$; $P < 0.05$) between the number of young male bears compared to adult male bears caught during the spring and summer. Proportionately, more young males were caught during the summer. No difference was found between the numbers of young females to old females caught during the spring and during the summer ($X^2 = 0.0$).

Preliminary returns of movements of the four female bears tagged during May 1979 with satellite monitored transmitters show that all bears stayed near shore or moved on to land by August. Some adult males occasionally wander inland for a short time, or they may spend the summer on pan ice. Although Johnson et al. (1976) saw no family groups among bears floating on ice in Lancaster Sound after June 6, the sex and age structure of these bears is not known. Jonkel (1976) proposed that some adult males may go high on the ice caps of glaciers to summer dens, but the extent to which this occurs is also unknown. The results therefore, suggest that summer retreats in Lancaster Sound are important for females of all ages, females with cubs, subadult males, but not adult males.

Summer retreats may be important for maintenance of polar bear populations since females with cubs and young bears are most important for population recruitment. However, more information is needed about environmental conditions which determine use of summer retreats, the selective advantages of summer retreats, and their importance to the maintenance of local populations during the period of minimum ice cover. In the event of an oil spill, summer retreats are the most likely places for polar bears to become fouled with oil or to encounter dead birds or sea mammals covered with oil.

Fall and Winter

Stepney (1976) found polar bears along both coasts and the eastern floe edge during the winter (March). Pond Inlet hunters report the north coast of Bylot Island, close to the floe edge of Lancaster Sound, to be a more important wintering area for polar bears than any other area in the vicinity of Pond Inlet (Hawkins, N.W.T. Wildlife Service pers. comm.). We conducted no surveys on polar bears during the fall and winter, but assume that as freeze-up progresses, bears move onto the ice from where they spend the summer, and their mid-winter distribution is similar to that of late winter.

Movements of Marked Polar Bears

Late Winter to Late Winter

Distances are expressed as the mean $\pm$ SD $t_{.05,v}$: i.e. 95% confidence interval and all tests for differences between sample means were at the 0.05

significance level. There was no overall pattern of movement for polar bears captured between mid-March and June of one year and recaptured or killed during the same period in succeeding years (Fig. 7). However, bears were frequently recaptured or killed near the areas of their original capture. Females were recovered an average of 198 ± 96 km (n=18) away and males 167 ± 88 km (n=11). There was no significant difference between the distances moved by males and females ($P(t_{05,27} \geq 0.4762) > 0.5$). The average combined distance travelled for males and females was 186 + 65 km (n=29).

There was no significant difference between the average movement of females recorded by Stirling et al. (1978) and that found in this report ($0.5 > P(t_{05,56} \geq 1.092) > 0.2$). However, a difference was evident in male movements ($0.05 > P (t_{05,77} \geq 2.074) > 0.02$) found in the two studies, with bears marked during this study moving significantly further during the same period.

One bear, a 6 year-old male at the time of capture, and not included in the above calculations, was captured at Durbin Island near Cape Dyer in 1976 and recaptured in 1979 on southeast Bylot Island, 860 km away.

Late Winter to Fall and Winter

The mean movement of bears tagged in mid-March to mid-June and killed or recaptured during October to February in subsequent years was 244 ± 430 km (N=3) for females and 387 ± 103 (n=11) for males (Fig. 8). There was no significant difference between distances moved by males and females ($0.5 > P (t_{05,12} \geq 1.33) > 0.2$). The combined mean was 357 ± 95 (n=14).

Polar bears killed or captured during the fall and winter were significantly further ($0.005 > P (t_{05,41} \geq 3.098) > 0.002$) from their late

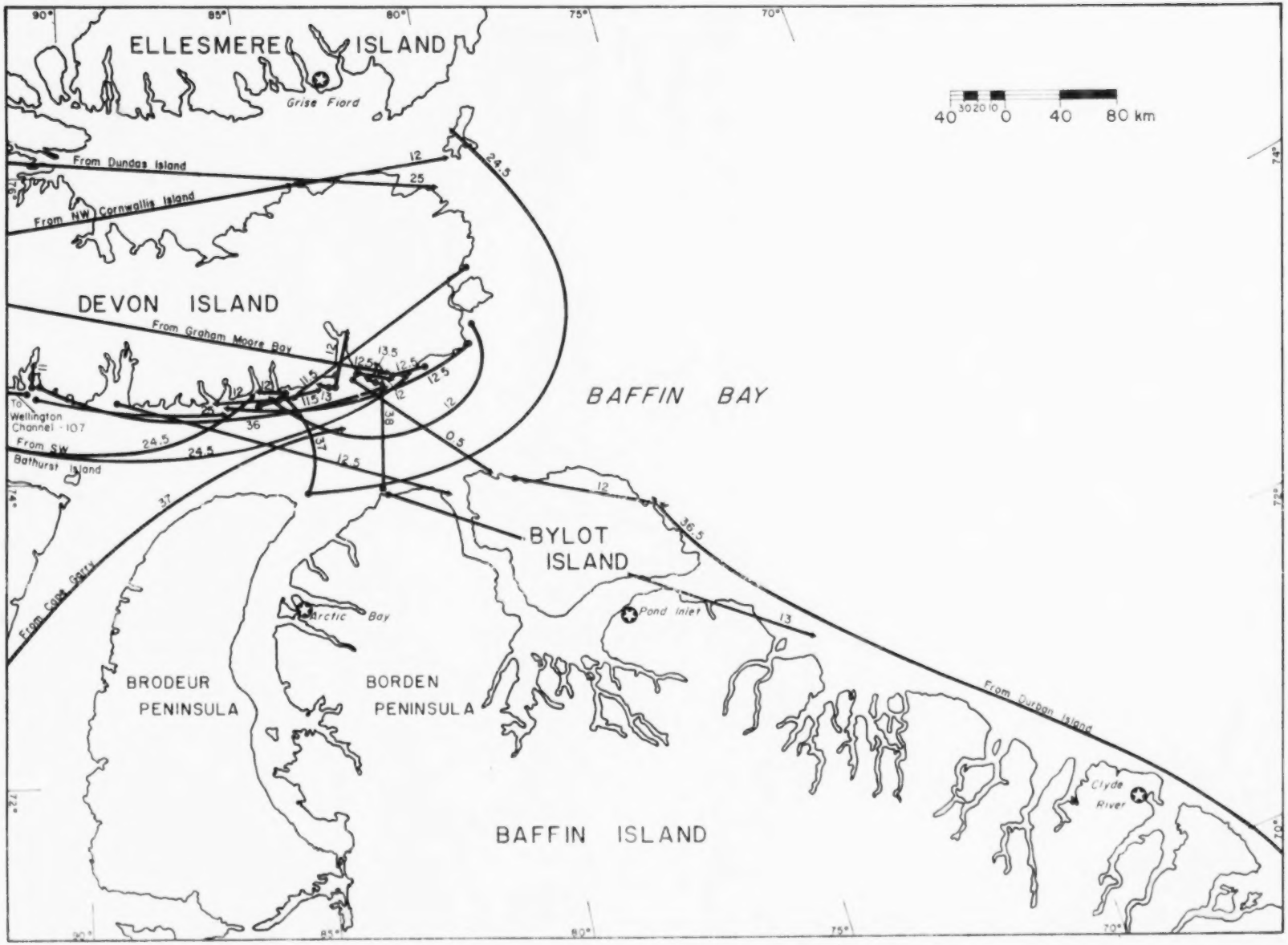

Fig. 7 Movements of polar bears captured during late winter (mid-March to mid-June) and recaptured or killed during the same season in succeeding years. Numbers on arrows indicate months between occurrences.

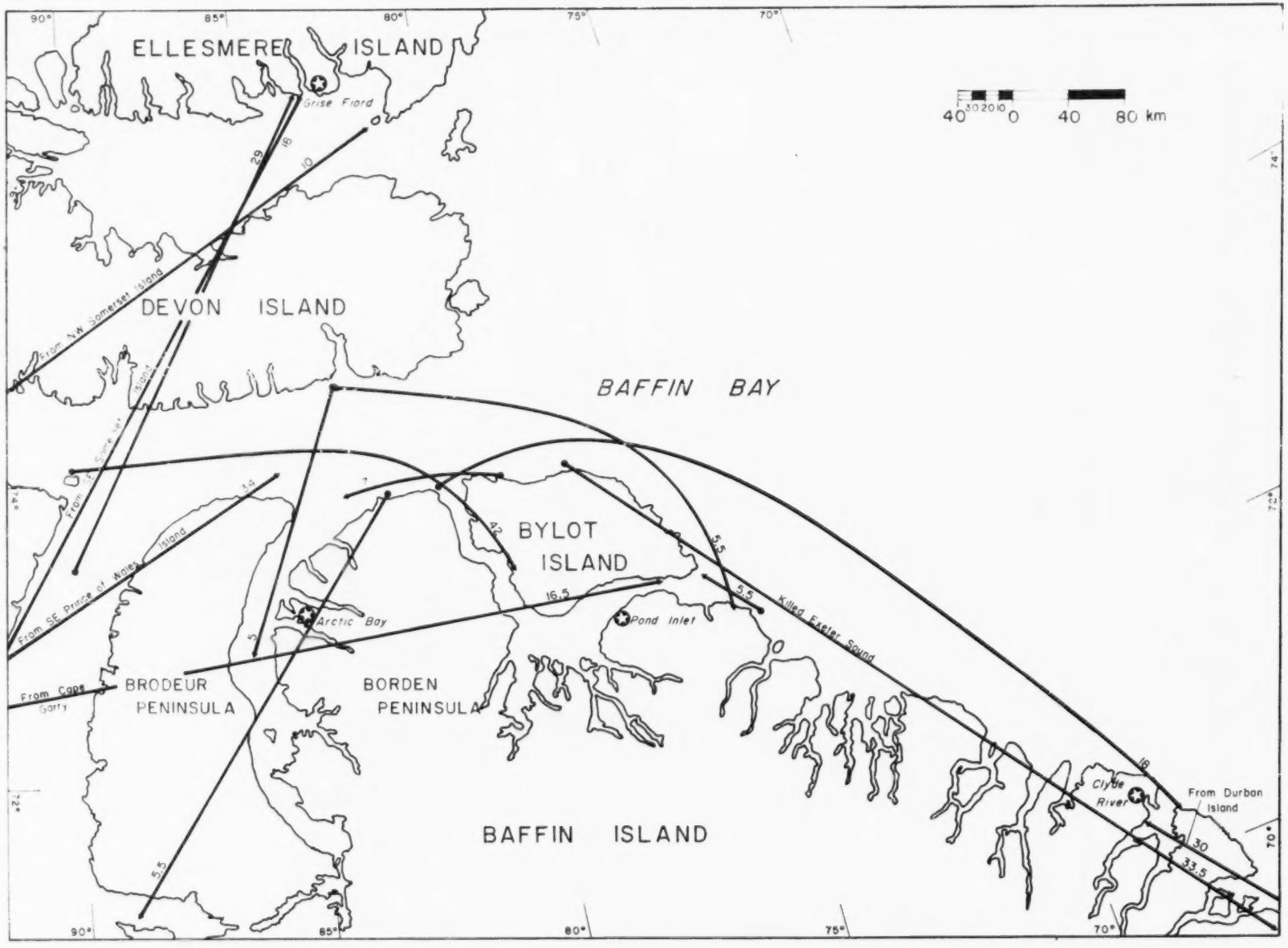

Fig. 8 Movements of polar bears captured during late winter (mid-March to mid-June) and

winter capture sites than were those that were returned during the late winter (see preceding section). This was probably due to a wide dispersal of bears caused by summer breakup of the ice, followed by a gradual return to late winter areas.

Summer to Summer

Within the study area, we have only 11 movements for four bears to determine fidelity to summer areas. All those sightings were in Radstock Bay, and are therefore highly biased. The bears moved 36.6 ± 24 km (n=11) between their points of original capture and subsequent recaptures. Two of the four were females (15.6 ± 11.4 km, n=5) with older cubs and two were adult males (54 ± 44 km n=6).

Summer to Late Winter

There appeared to be an easterly movement of the bears captured between mid-June and the end of August of one year, and mid-March to mid-June of succeeding years (Fig. 9). Many of the bears captured in Radstock Bay during the summer later moved to east Lancaster Sound.

Movements of males during this period averaged 139 ± 59 km (n=6) and females averaged 223 ± 75 km (n=10) with no difference between the sexes ($0.1 > P\ (t_{05,14} \geq 1.883) > 0.05$). Combined movements averaged 191 ± 52 km (n=16).

There was no difference between the mean distance travelled by the bears of this study and those reported in Stirling et al. (1978) ($P\ (t_{05,34} \geq 0.631) > 0.5$) during the same period. There was also no difference between

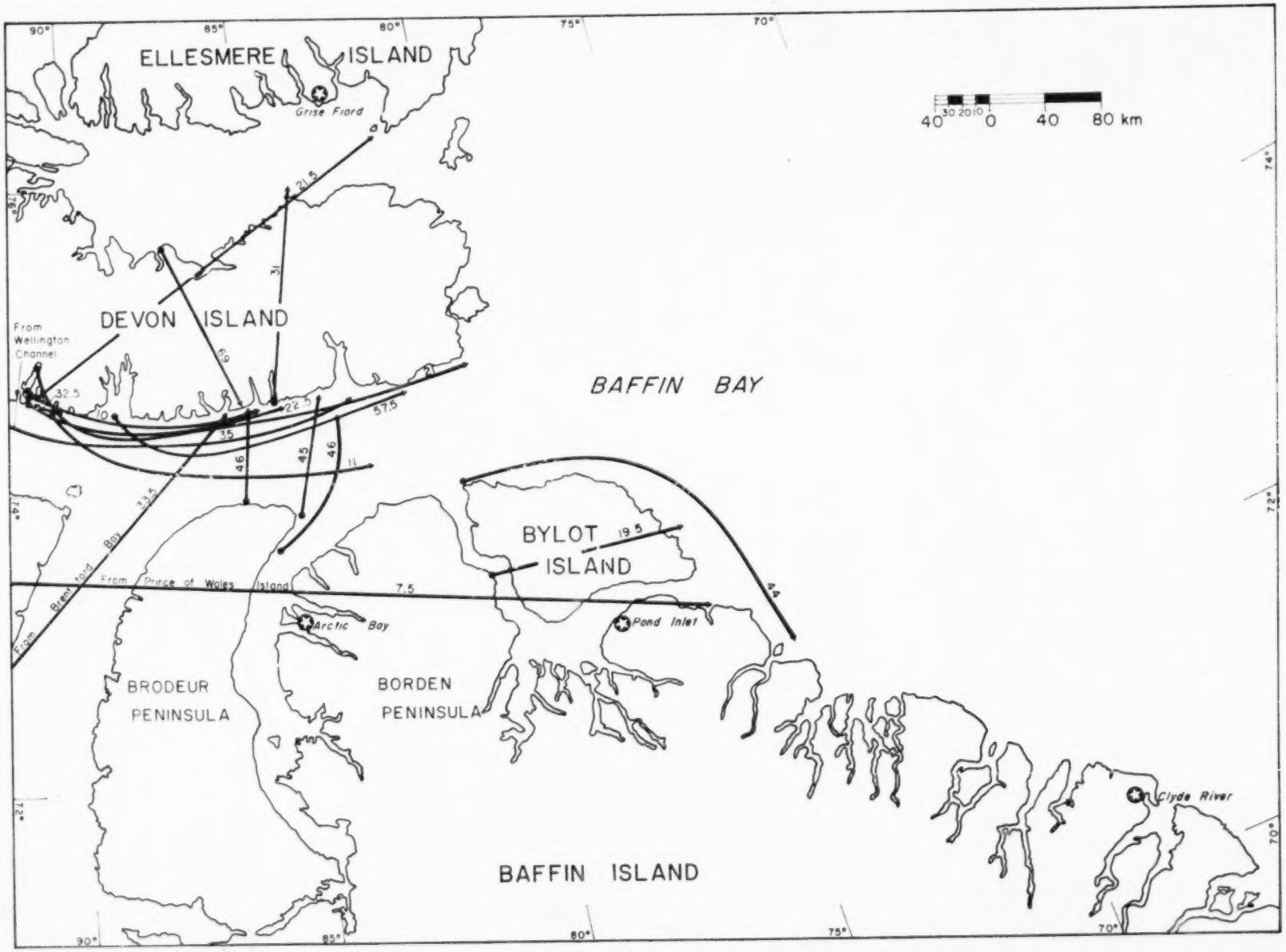

Fig. 9 Movements of polar bears captured between mid-June and the end of August and recaptured or killed between mid-March and mid-June in succeeding years. Numbers

the movements of bears of this period (summer to late winter) and those of late winter to late winter ($P\ (t_{05,43} \geq 0.111) > 0.5$).

Not included in these calculations is the movement of a bear which travelled the furthest distance. A 4 year-old male was tagged on the east coast of Prince of Wales Island in August 1977 and killed near Pond Inlet in March 1978, a distance of over 700 km. As the ice melts from east to west, many bears probably move west to areas such as Radstock Bay, and return to east Lancaster Sound when the ice reforms.

Late Winter to Summer

Of bears originally captured in mid-March to mid-June few were recaptured during mid-June to August. No statistical comparisons were made due to the insufficient sample size. Average male movement was 142 $\pm$ 293 km (n=3) and average female movement was 47 $\pm$ 35.9 km (n=2). The combined mean movement was 104.2 $\pm$ 121.6 (n=5).

Short-term Movements from Resightings of Marked Bears

Figure 10 illustrates the short-term movements of bears based on resightings obtained during the 1978 and 1979 field seasons. During 1978, only seven of the 54 marked bears were resighted. The most notable short-term movement during 1978 was that of a sub-adult female captured at the mouth of Croker Bay and resighted northwest of Cape Hay 16 days later.

During 1979, 61 of the 176 captured bears were resighted. Some bears remained in the same area after capture, whereas others moved considerable distances. For example, four adult females moved 330 km in 2 days, 260 km

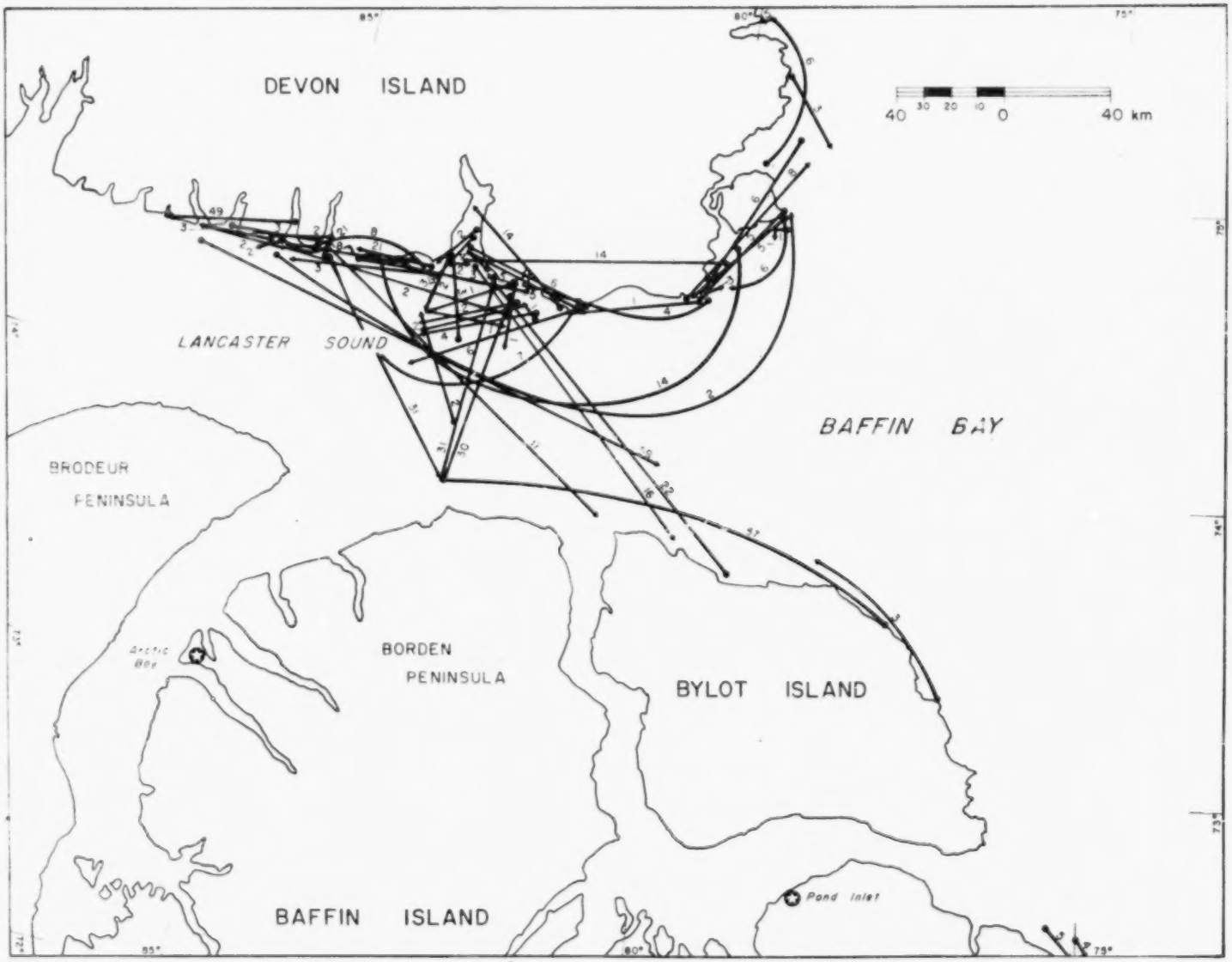

Fig. 10 Short-term movements of polar bears based on resightings during April and May of 1978 and 1979. Numbers on arrows indicate the number of days between occurences.

in 7 days, 250 km in 14 days, and 225 km in 22 days, respectively. In contrast, two adult females and two adult males were resighted no more than 5 km from their points of capture an average of 6.5 days later.

There did not appear to be any directional trend in movements subsequent to capture, although bears captured close to shore tended to be resighted close to shore.

Similarly, preliminary results from three of the four satellite monitored females showed that the bears remained close to land and moved no more than 30 km from their points of capture during the first month.

More search time was spent and more bears were captured in inshore areas. The majority of resightings therefore, could be expected to be inshore. Although this observer bias exists, the 35% resighted proportion is unusually high compared to other mark-recapture studies (Stirling et al. 1975). This may indicate a largely inshore based population of bears, at least at the time of our study.

Subpopulation Range

It is clear from mark-recapture results that the bears of Lancaster Sound belong to the same subpopulation as those of Prince Regent Inlet, Barrow Strait, Wellington Channel and Jones Sound (Fig. 11). There also appears to be a connection between the bears of Lancaster Sound and those along northeast Baffin Island, at least as far as Clyde River and perhaps Cape Dyer. The relationship of Lancaster Sound bears to those of Greenland is still not clear. One bear captured in Strathcona Sound and another tagged in Norwegian Bay were shot in Greenland (Stirling et al. 1978). Further

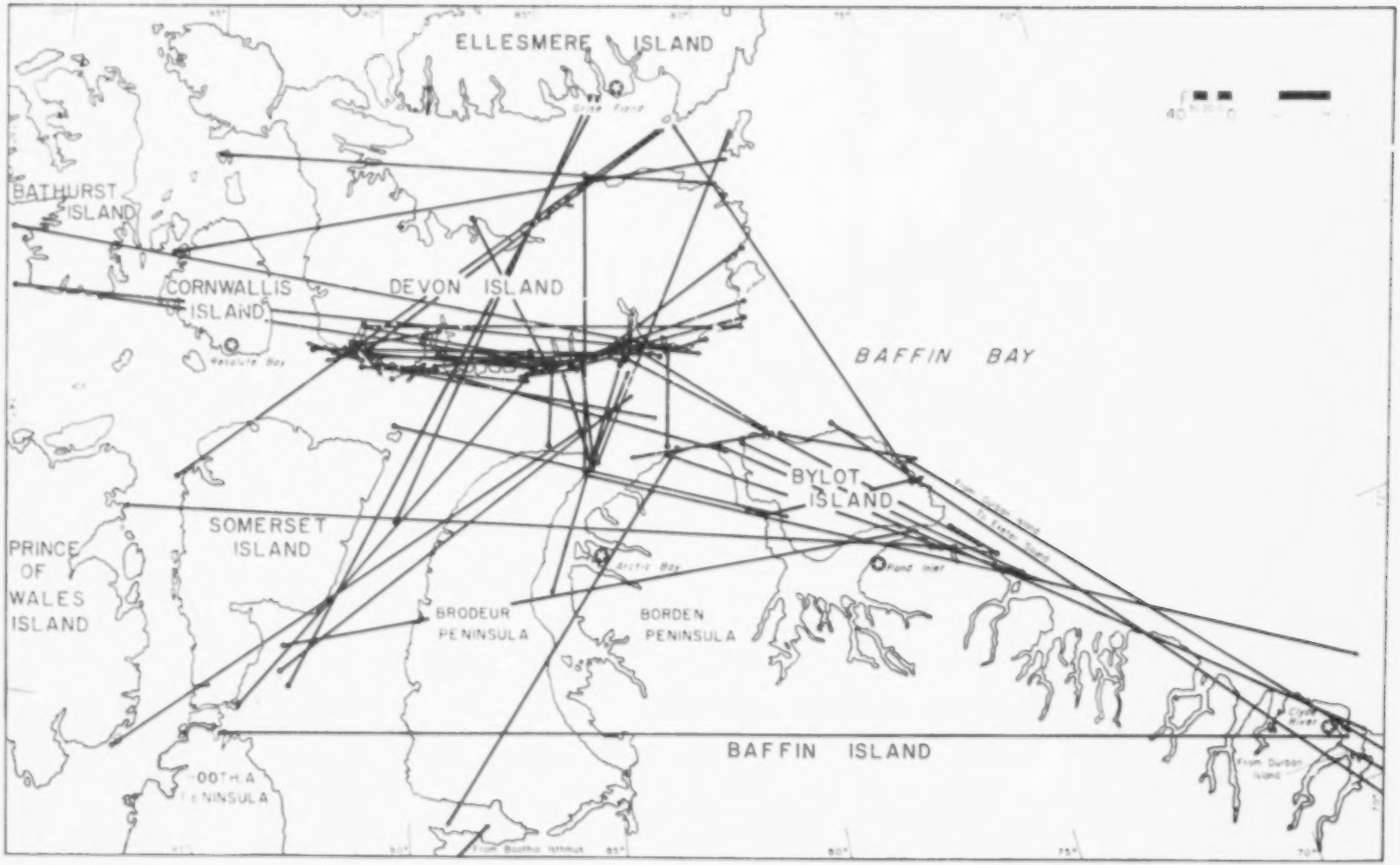

Fig. 11 Movements of polar bears captured during any season and recaptured or killed during any season in succeeding years (from capture information 1978, 1979 and hunter kill returns from 1977-78 and 1978-79).

weight is added to the possibility of an internationally shared population when the vast unpopulated area and the chances of recovery of a tag are considered.

Maternity Denning Areas

Three dens were located and examined in the area (Fig. 12). One on southeast Bylot Island was thought to be a temporary den occupied by a female and cub of the year on their way from the maternity den to the sea ice. Seven den sites were reported on the east and north coasts of Bylot Island. A ground survey was conducted on north Borden Peninsula, but surprisingly no dens were found there.

Sightings of females with cubs of the year provided most of the information about denning areas within Lancaster Sound. The information gathered during the E.A.M.E.S. study was combined with that previously reported in Schweinsburg et al. (1977) (Fig. 12). As cubs of the year are small and have difficulty keeping up on long travels, females with cubs of the year sighted on the sea ice before the middle of April are likely close to the land area where their maternity dens are located. Because of increased family mobility, sightings after the middle of April become progressively less reliable as indicators of maternity denning sites.

Family groups with newborn cubs were seen during April at Radstock Bay, Croker Bay, Cape York and Bylot Island (Fig. 12). No large concentrations of dens or family groups were found. This was also reported by Stirling et al. (1978) who concluded that sparsity of dens and family groups could result from either an artifact of our survey techniques, or more likely that the

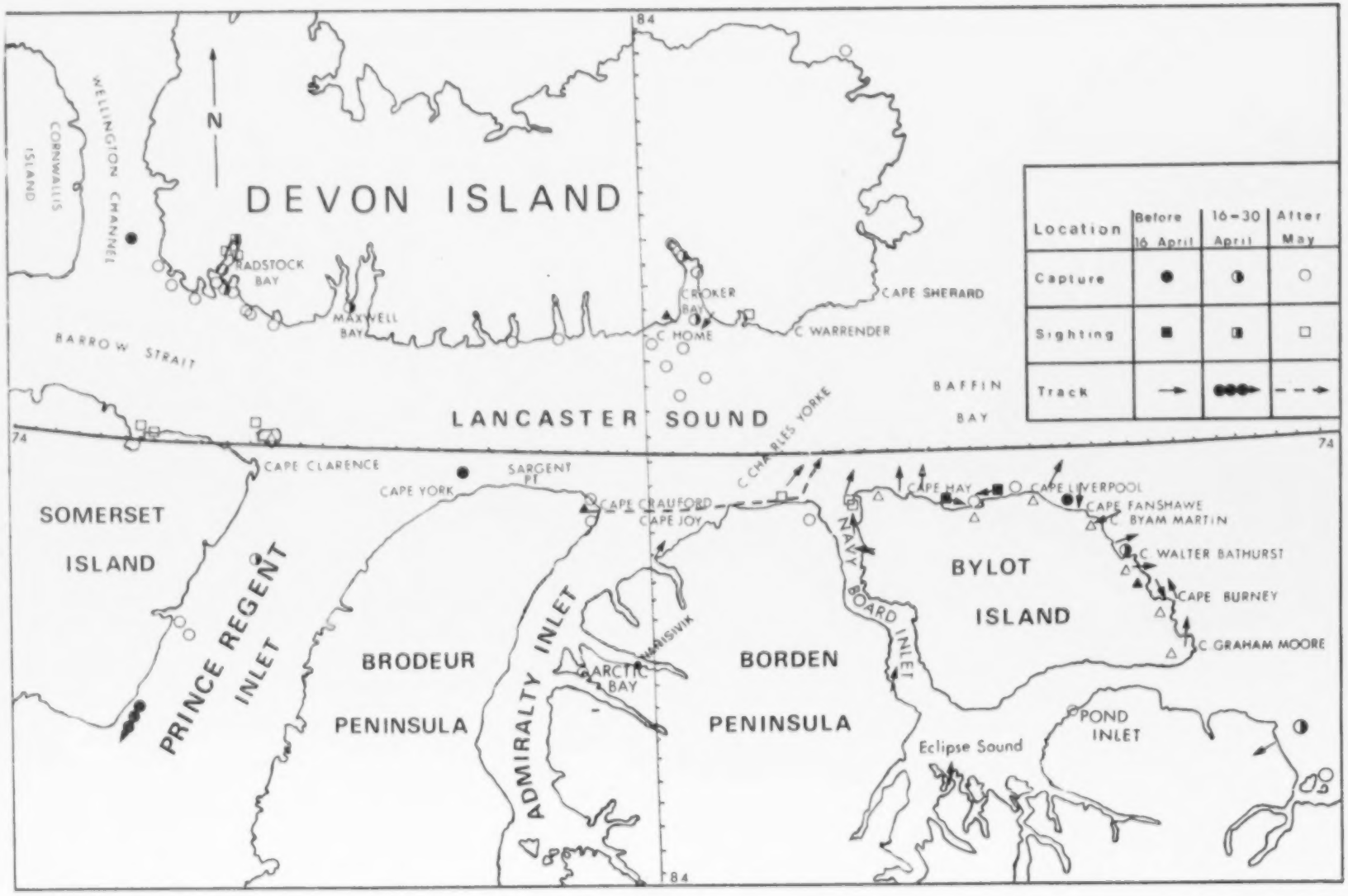

Fig. 12 Summary of denning information for Lancaster Sound and adjacent areas (from this study and Schweinsburg et al. 1977).

large amount of denning habitat in the Arctic Islands allowed for widely dispersed denning. The latter explanation seems more plausible. Elsewhere it was noted that boundaries of summer retreats appear to coincide with, or are near denning areas (NWTWS Map Series of Important Polar Bear Habitat). In a general way, this seems to hold true for the Lancaster Sound area as well.

Population Structure

Estimates of Numbers

Table 4 shows the population estimates N_i for eastern Lancaster Sound based on this study and all previous studies. Only the estimate for 1979, 1031 $\pm$ 236 bears, has a standard error low enough to be of value. The estimate of Stirling et al. (1978) for the total F Zone was 1675 bears in 1977. When the data from this study were combined with their data, the estimate for the total F Zone during 1979 was 1647 bears (Table 5). These estimates should be treated with caution since the sampling was localized. Because of this, however, it was felt that the estimates of both Lancaster Sound and total F Zone are probably minimal. Because of the large number of marked bears now in Lancaster Sound, another sample of adequate size should yield a reliable population estimate.

Sex Ratio

The age distribution for the capture and kill samples are given by sex in Tables 6 and 7. The eastern Lancaster Sound capture sample had a 1:1 sex ratio ($0.1>P\ (X^2_{.05,1}\geq 2.94)>0.05$); however the sex ratio for the capture

Table 4. Summary of mark-recapture data from eastern Lancaster Sound and estimates of population size (N_i).

Year	1970/72	1973	1974	1975	1976	1977	1978	1979
i	1	2	3	4	5	6	7	8
n_i	4	9	11	33	64	5	56	176
m_i	0	1	1	0	0	1	2	21
R_i	3	9	11	29	64	5	55	175
P_i	-	.11	.09	0	0	.2	.036	.119
M_i	-	2.66	9.43	17.20	40.89	92.83	85.69	122.74
S_eM_i	-	.54	1.29	2.11	4.03	8.03	9.27	12.38
N_i	-					464	2380	1031
S_eN_i	-					416.7	1695.8	236.3

n_i The total number of bears captured on the ith sample.

m_i The total number of previously marked bears captured in the ith sample.

R_i The total number of marked animals (including recaptures) released in the ith sample.

P_i The proportion of animals marked in the population.

M_i The number of tagged animals available for sampling just prior to the ith sample.

S_eM_i The stardard error of M_i.

N_i The number of animals present in the population at time i.

S_eN_i The standard error of N_i.

ϕ .885.

Table 5. Summary of capture-recapture data from F Zone and population estimates (N_i). (Adapted from Stirling et al. 1978).

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
i	1	2	3	4	5	6	7	8	9	10
n_i	18	19	57	45	48	79	102	110	72	176
m_i	0	0	6	9	6	5	13	14	7	31
R_i	18	19	57	44	48	73	102	108	68	175
P_i	—	—	.105	0.2	.125	.063	.127	.127	.097	.176
M_i	--	15.68	30.22	70.77	92.16	116.89	161.09	217.9	271.76	289.93
S_eM_i	—	1.71	3.10	5.93	8.40	10.95	14.44	19.06	24.20	28.19
N_i	—					1855.4	1268.4	1715.7	2801.6	1647.3
S_eN_i	—					821.25	342.34	445.9	1031.1	290.4

n_i The total number of bears captured on the ith sample.

m_i The total number of previously marked bears captured in the ith sample.

R_i The total number of marked animals (including recaptures) released in the ith sample.

P_i The proportion of animals marked in the population.

M_i The number of tagged animals available for sampling just prior to the ith sample.

S_eM_i The standard error of M_i.

N_i The number of animals present in the population at time i.

S_eN_i The standard error of N_i.

ϕ .871.

Table 6. Number of polar bears captured-recaptured in the Lancaster Sound area 1978 and 1979 and killed by hunters from Arctic Bay and Pond Inlet during 1977/78.

Age	Capture 78/79		Kill 77/78	
	Male	Female	Male	Female
0	14	13	0	0
1	4	5	1	0
2	4	8	0	2
3	4	13	2	1
4	9	15	2	2
5	7	15	7	0
6	7	9	4	0
7	8	7	0	1
8	7	9	0	2
9	3	7	1	0
10	3	3	0	1
11	6	5	0	0
12	6	3	0	1
13	4	0	0	0
14	2	4	1	0
15	0	1	0	0
16	1	2	0	0
17	1	1	0	0
18	3	0	0	0
19	2	2	0	0
20	3	2	0	0
21	2	1	0	0
22	0	2	0	0
23	1	0	0	0
24	1	0	0	0
25	0	1	0	0
Total	102	128	18	10

Table 7. Number of polar bears captured-recaptured in F Zone 1970-1979 and killed by hunters from Grise Fiord, Pond Inlet, Arctic Bay and Resolute Bay from 1970-1978.

	Capture		Kill	
Age	Male	Female	Male	Female
0	54	55	0	1
1	21	28	11	8
2	21	30	16	23
3	19	21	36	12
4	28	31	25	17
5	19	28	37	12
6	24	20	17	7
7	21	14	15	6
8	13	26	11	11
9	10	21	14	1
10	8	13	3	5
11	17	16	6	4
12	8	7	3	2
13	5	11	1	1
14	8	13	2	1
15	4	7	4	2
16	1	7	3	1
17	1	4	1	0
18	3	2	2	1
19	2	5	2	0
20	5	4	2	1
21	3	1	0	0
22	0	3	0	0
23	1	2	1	1
24	2	0	0	0
25+	0	6	2	0
Total	298	375	214	117

sample for the entire F Zone was unbalanced in favor of females (1:0.8) ($.005>P(X^2_{05,1}\geq 8.81)>.001$). The sex ratio of cubs of the year for both groups of data was 1:1.

The lower frequency of males in F Zone may be due to sampling biases prior to 1974 when preference was given to females and family groups. However it could be a function of higher hunting pressure on males. Significantly, more males than females ($.005>P(X^2_{05,1}\geq 8.34)>0.001$) were killed by hunters. The proportion of captured males (0.423) and killed males (0.647) is approximately 1.0. This is similar for captured and killed females. Thus we assume that the unbalanced sex ratio is due to selective hunting of males which is encouraged by NWTWS regulations.

Productivity

The productivity calculations were based on the data presented in Tables 8 and 9 respectively for eastern Lancaster Sound and all F Zone. Only 28% of adult females in eastern Lancaster Sound were accompanied by cubs of any age. Of all the family groups, 64% were Coy, 28% were yearlings and 8% were composed of 2 year-olds. The difference of over 50% between the number of Coy groups and yearling groups is much higher than the 23% and 28% difference respectively found in E Zone (Schweinsburg et al. 1979) and previous studies in F Zone (Stirling et al. 1978). This is possibly a reflection of a poor breeding year during 1978 in Lancaster Sound.

Table 8. Number of females with young captured in eastern Lancaster Sound area 1978 - 1979.

Age	No. of females in age group	No. of females with cubs	Coy 1	Coy 2	Yearlings 1	Yearlings 2	2 yr-olds 1	2 yr-olds 2
3								
4	15	2		2				
5	15	1	1					
6	9	3	2		1			
7	7	3		2				1
8	9	4	2	1			1	
9	7							
10	3	2		1	1			
11	5	2		1	1			
12	3	1		1				
13	0							
14	4	3		2		1		
15	1							
16	2	1		1				
17	1							
18	0							
19	2							
20	2	1			1			
21	1	1			1			
22	2	1				1		
23	0							
24	0							
25	1							

Table 9. Family groups captured in F Zone 1970-1979.

Age	No. of females in age group	No. of females with cubs	Coy		Yearlings			2 yr-olds	
			1	2	1	2	3	1	2
3	21	0	-	-	-	-	-	-	-
4	31	2	-	2	-	-	-	-	-
5	28	7	5	1	1	-	-	-	-
6	20	12	3	2	2	3	-	2	-
7	14	8	-	6	-	1	-	-	1
8	26	13	4	5	1	1	-	2	-
9	21	11	2	5	2	1	-	-	1
10	13	9	1	3	3	2	-	-	-
11	16	7	1	3	1	1	-	1	-
12	7	4	1	2	1	-	-	-	-
13	11	6	-	-	1	4	-	-	1
14	13	9	-	5	-	3	-	-	1
15	7	3	-	-	-	2	1	-	-
16	7	5	2	2	-	-	-	-	1
17	4	1	-	-	1	-	-	-	-
18	2	2	1	1	-	-	-	-	-
19	5	3	-	1	-	1	-	1	-
20	4	2	-	1	1	-	-	-	-
21	1	1	-	-	1	-	-	-	-
22	3	1	-	-	1	-	-	-	-
23	2	1	-	1	-	-	-	-	-
24+	6	0							

Litter Size

Table 10 summarizes the calculations of age-specific litter size for the total F Zone. The weighted litter size for eastern Lancaster Sound was 1.56 (± 0.1 (SE) n=25) cubs/litter. This was slightly higher than that found earlier (Schweinsburg et al. 1977) for the same area, (1.42 cubs/litter) but lower than that of 1.6 (± 0.05 (SE) n=106) calculated for all of F Zone. Litter size of E Zone bears (Schweinsburg et al. 1979 and Stirling et al. 1978) was slightly smaller than that found in this study (Table 11).

Our data indicate that there was mortality resulting in smaller litter sizes for F Zone as the cubs of the year (1.68 ± 0.06 (SE) n=59) grew to yearlings (1.58 ± 0.09 (SE) n=36) to 2 year-olds (1.43 ± 0.16) (SE) n=11). However there was no statistically significant change in litter size ($0.5>P(F_{05(1)2,23} \geq 1.075)> 0.25$. When the litter sizes from eastern Lancaster Sound were considered alone, (cubs of the year 1.69 (± 0.12 (SE) n=16, yearlings 1.29 (± 0.18 (SE) n=7) and 2 year-olds 1.5 (± 0.49 (SE) n=2) cubs/litter), there was also no significant difference between the litter size of cubs of the year and yearlings ($0.1>P)t_{05,21} \geq 1.97)> 0.05$).

Although the proportion was small, in eastern Lancaster Sound a few females bred for the first time during their 3rd year with parturition during the 4th. Most began breeding during the 4th year however (Table 9). This was also found by Stirling et al. (1978) and Schweinsburg et al. (1979) for the central Arctic. This was 1 year earlier than bears from the Beaufort Sea (Stirling et al. 1975). Our sample size was small. For comparison, however, more information is needed on the breeding biology of polar bears in Lancaster Sound.

Table 10. Calculation of age-specific litter size for all of F Zone.

	No. of females with cubs			No. of cubs					
	F_o	F_1	F_2	C_o	C_1	C_2			Litter size
Age	No. of X females	No. of X + 1 females	No. of X + 2 females	No. of Coy	No. of yearlings	No. of 2 yr-olds	F	C	$\frac{C}{F}$
3	0	0	0	0	0	0	0	0	0
4	2	1	2	4	1	2	5	7	1.4
5	6	5	1	7	8	2	12	17	1.42
6	5	1	2	7	2	2	8	11	1.38
7	6	2	1	12	3	2	9	17	1.89
8	9	3	0	13	4	0	12	17	1.42
9	7	4	1	12	6	1	12	19	1.58
10	4	3	0	7	4	0	7	11	1.57
11-14	12	12	3	22	23	6	27	51	1.89
15-18	6	2	1	9	3	1	9	13	1.44
19-24	3	3	0	6	3	0	6	9	1.50
	60	36	11	99	57	16	107	172	

Weighted litter size:

$$= \frac{\sum_4^{24} C_o + \frac{\sum_4^{24} C_1}{\emptyset} + \frac{\sum_4^{24} C_2}{\emptyset^2}}{\sum_4^{24} F_o + \frac{\sum_4^{24} F_1}{\emptyset} + \frac{\sum_4^{24} F_2}{\emptyset^2}}$$

= 1.6 cubs/litter

$\emptyset$ = 0.871 = Survival.

Table 11. Summary of litter sizes, probability of parturition and natality rates for eastern Lancaster Sound, F Zone and E Zone.

Location	Weighted mean litter size	Weighted mean probability of parturition	Weighted natality rate
Eastern Lancaster Sound 1978 and 1979	1.56 (25)	0.139 (89)	0.217
F Zone 1970-1979	1.598 (107)	0.210 (241)	0.336
F Zone 1970-1977* Stirling et al. 1978	1.69 (62)	0.249** (217)	0.421
E Zone 1972-1978 Schweinsburg 1979	1.527 (77)	0.287 (116)	0.438

* Unweighted values.
** Calculated as mean litter - produced rate.

Probability of Parturition

Table 12 summarizes the calculated age-specific probabilities of parturition (the probability that a female will have a cub that year) for all the data of F Zone. The weighted mean probability of parturition was 0.210.

Natality Rates

Calculations of age-specific natality rates are presented in Table 13. The weighted mean natality rates for F Zone and for eastern Lancaster Sound were calculated to be 0.336 and 0.217 cubs per year per female respectively. Previous work in F Zone (Stirling et al. 1978) indicated a natality rate of 0.421. The lower rate in this study is a reflection of the lower probability of parturition found during 1978 and 1979 in eastern Lancaster Sound. The reason for this is not clear but could be a function of seal abundance or ice conditions. Because 1978 and 1979 accounted for more than 40% of the productivity information collected over the 9 year period, the overall natality rate is likely not as low as the data suggests.

Age Structure

The age structures from the kill and capture samples were tested in 2 X 12 and 2 X 14 contingency tables respectively to determine which samples could be pooled. The age structure of male and female capture samples from eastern Lancaster Sound were not significantly different ($0.75>P$ ($X^2_{05,13} \geq 10.8$) > 0.5) and hence were pooled. The kill sample from eastern Lancaster Sound from 1978 -79 was too small for analysis. Consequently the mortality

Table 12. Calculation of age-specific probability of parturition for F Zone 1970-1979.

C	Cx	Dx	Fx	Fx + 1	Cx + Dx	Fx + Fx+1	Cx + Dx / Fx + Fx + 1
Age	No. of females with Coy	No. of females with year-lings	No. of X females	No. of x + 1 females			
4	2	1	31	28	3	59	.05
5	6	5	28	20	11	48	.229
6	5	1	20	14	6	34	.176
7	6	2	14	26	8	40	.200
8	9	3	26	21	12	47	.255
9	7	4	21	13	11	34	.324
10	4	3	13	16	7	29	.241
11-14	12	12	47	38	24	85	.282
15-18	6	2	20	18	8	38	.211
19-24	3	3	21	16	6	37	.162
	60	36	241	210			

Weighted mean probability of parturition

$$\frac{\sum_{4}^{24} C_x + \frac{\sum_{4}^{24} D_x}{\emptyset}}{\sum_{4}^{24} F_x + \sum_{4}^{24} F_{x+1}}$$

$$= \frac{\sum_{4}^{24} C_x + \frac{\sum_{4}^{24} D_x}{\emptyset}}{\sum_{4}^{24} F_x + \sum_{4}^{24} F_{x+1}}$$

$$= 0.210$$

$$\emptyset = 0.871 = \text{Survival}$$

Table 13. Calculations of age-specific natality rates for F Zone. (Sample sizes in parentheses).

	Probability of parturition	Litter size	mx natality
4	0.05 (59)	1.4 (5)	0.07
5	0.229 (48)	1.42 (12)	0.325
6	0.176 (35)	1.38 (8)	0.243
7	0.200 (42)	1.89 (9)	0.378
8	0.255 (49)	1.50 (12)	0.383
9	0.324 (36)	1.59 (12)	0.515
10	0.241 (20)	1.57 (7)	0.378
11-14	0.282 (91)	1.89 (27)	0.533
15-18	0.211 (40)	1.44 (9)	0.304
19-24	0.162 (39)	1.50 (6)	0.243

= weighted mean natality rate

= weighted mean litter size X weighted mean probability of parturition

= 1.598 X 0.210

= 0.336

rates for this area were based on the capture sample only. An exponential curve (Fig. 13) fitted to the capture data from 0 - 25 years yielded a survival rate of .885 for eastern Lancaster Sound.

The four sample sources were compared for all of F Zone and only the age composition of the male and female capture samples (Table 8) were not significantly different ($0.25>P\ (X^2_{05,13} \geq 16.725)>0.1$). The age composition of killed males was found to be different from that of captured males, captured females, and killed females ($0.005 > P\ (X^2_{05,11} \geq 30.3) > .001$); $P\ (X^2_{05,11} \geq 41.4) < .001$; and $0.005 > P(X^2_{05,11} \geq 30.9) > 0.001$ respectively). The age composition of killed females was also significantly different from captured males and captured females ($0.05 > P(X^2_{05,11} \geq 21.5)> 0.025$; and $0.025 > P(X^2_{05,11} > 24.1) > 0.01$. Consequently, only the male and female capture samples were pooled for the calculation of F Zone mortality rate. Mortality rates were determined separately for killed males and killed females (Table 14).

The F Zone capture data from 0-25 years was fitted to an exponential curve which explained 90% of the variation (Fig.14) and yielded a survival rate of .871. Although the curve generally fit the data well, it underestimates the number of cubs of the year and overestimates the 1, 2, and 3 year age groups as illustrated by the broken line in Figure 14. Under-sampling of less mobile family groups could be the cause of their under-representation in the captures.

The fitted curve was used to establish age class frequencies which represented a cohort the size of the estimated F Zone population of 1,647 bears. Using these age class frequencies and the age-specific natality rates (Table 13), the annual number of cubs produced (Table 15) was estimated to be 185.

Table 14. Mortality rates of kill and capture samples calculated by fitting exponential curves to the age structures.

Sample group	Year classes over which curves fitted	Annual mortality rate
Captured male and female eastern Lancaster Sound	0 - 25	11.5%
Captured male and female F Zone	0 - 25	12.9%
Killed male F Zone	2 - 25	13.3%
Killed female F Zone	2 - 25	12.4%

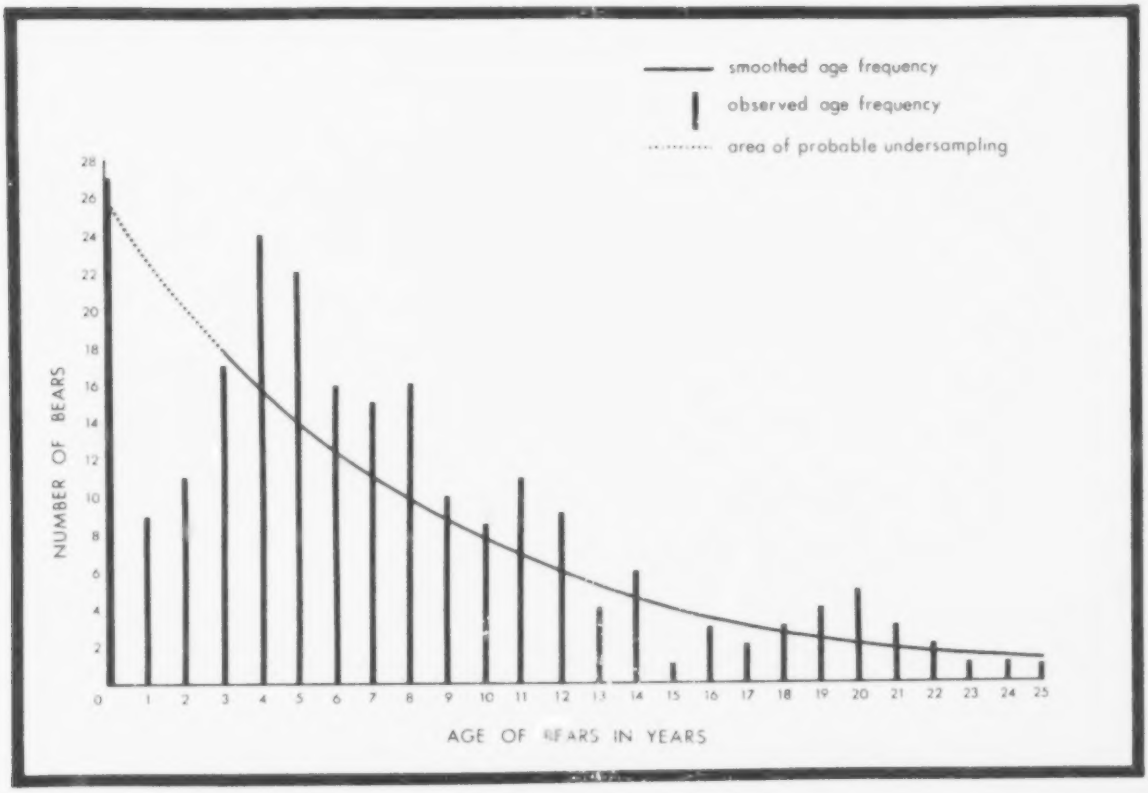

Fig. 13. Age frequency curve based on the capture data from eastern Lancaster Sound, 1978,1979.

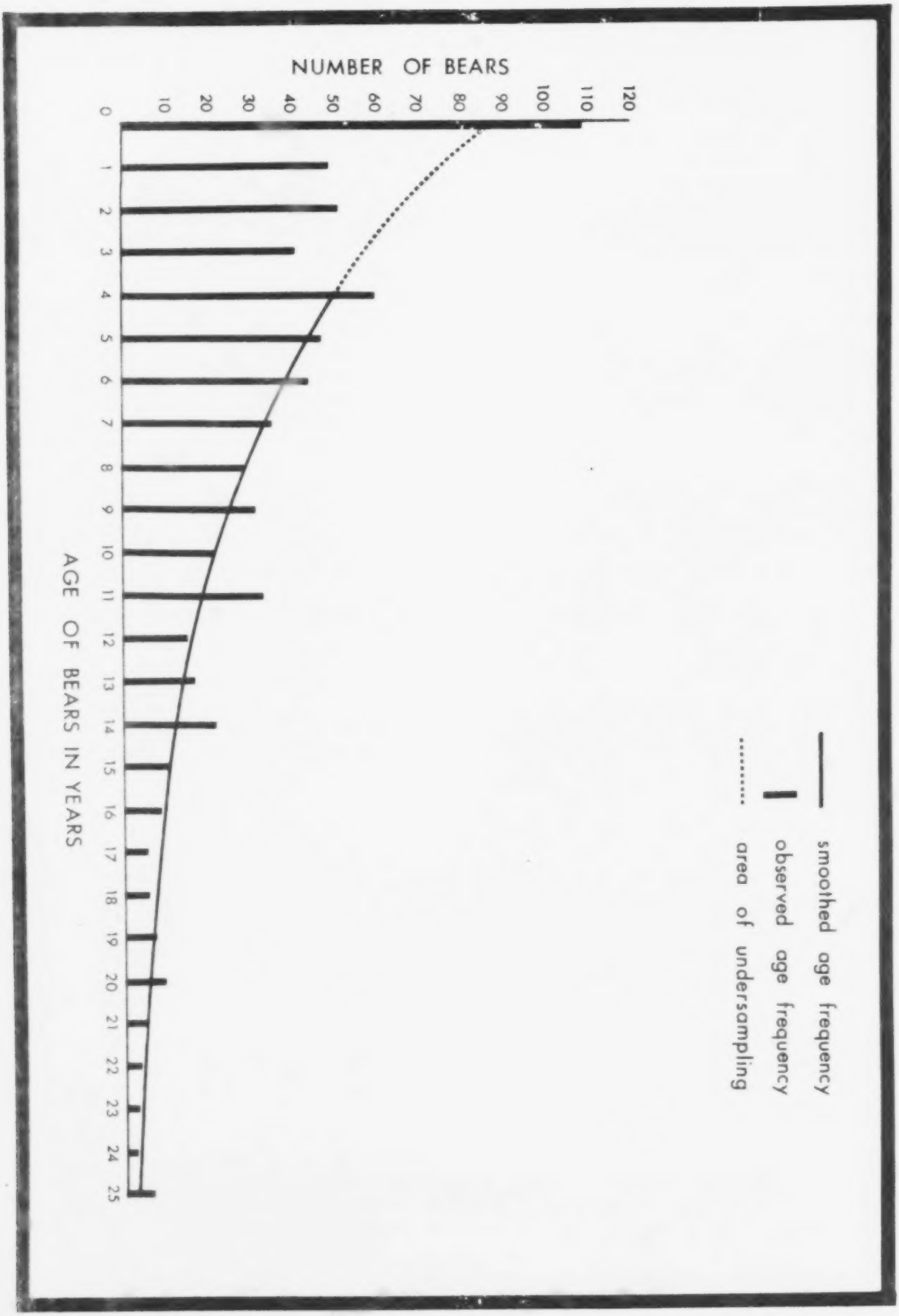

Fig. 14. Age frequency curve based on the capture data from all of F Zone.

Table 15. Number of cubs produced per year in F Zone using age-specific natality rates from Table 13 and female age class frequencies derived from the exponential curve fitted to the raw age structure data (Fig. 14). The age class frequencies were expanded to represent a cohort of 1,647 bears.

Age (years)	Number of females	Natality rate	Cubs produced
0	121.48	-	-
1	105.84	-	-
2	92.22	-	-
3	80.34	-	-
4	70.00	0.070	4.9
5	60.99	0.325	19.82
6	53.14	0.243	12.91
7	46.30	0.378	17.50
8	40.33	0.383	15.45
9	35.14	0.515	18.10
10	30.62	0.378	11.57
11-14	87.34	0.533	46.55
15-18	50.33	0.304	15.30
19+	42.34	0.243	10.29
			172.39

The product of mortality rate (12.9%) and estimated population size yielded an overall annual mortality of 212 animals. Ninety-four of these were killed by hunters from Resolute Bay, Arctic Bay, Pond Inlet and Grise Fiord; approximately 44% of the annual mortality. This results in an approximate annual natural mortality of 7.2% for the population of F Zone. Analysis of covariance found no significant differences between mortality rates of captured bears from eastern Lancaster Sound, F Zone, killed males F Zone or killed females F Zone ($P(F_{.55,(2),3,92} \geq 0.415) > 0.5$. The estimate of the common underlying slope and consequent survival rate was calculated (Zar 1974) as 0.876.

Hunter Kill

Figure 15 shows the locations of hunter kills of polar bears from 1976 to 1979 in the study area. Resolute Bay hunters kill bears in Barrow Strait and west Lancaster Sound. People from Arctic Bay hunt in the mouth of Admiralty Inlet, and those from Pond Inlet around Bylot Island. The kills by Arctic Bay, Pond Inlet, and Resolute Bay hunters in Prince Regent Inlet are the result of a recently allocated quota for that area. Grise Fiord hunters kill bears mostly in Jones Sound, and Clyde River hunters concentrate on the area along the northeast Baffin coast. These hunting patterns may account for the relatively high densities of polar bears along the south Devon coast (see Late Winter Distribution), an area not hunted.

The pre-1979-80 hunting season extended from 10 October to 31 May. Arctic Bay, Pond Inlet and Clyde River took many of their bears in autumn, whereas Grise Fiord and Resolute Bay hunted mostly in late winter (Table 16). Autumn hunting is not desirable because pregnant females are shot before they

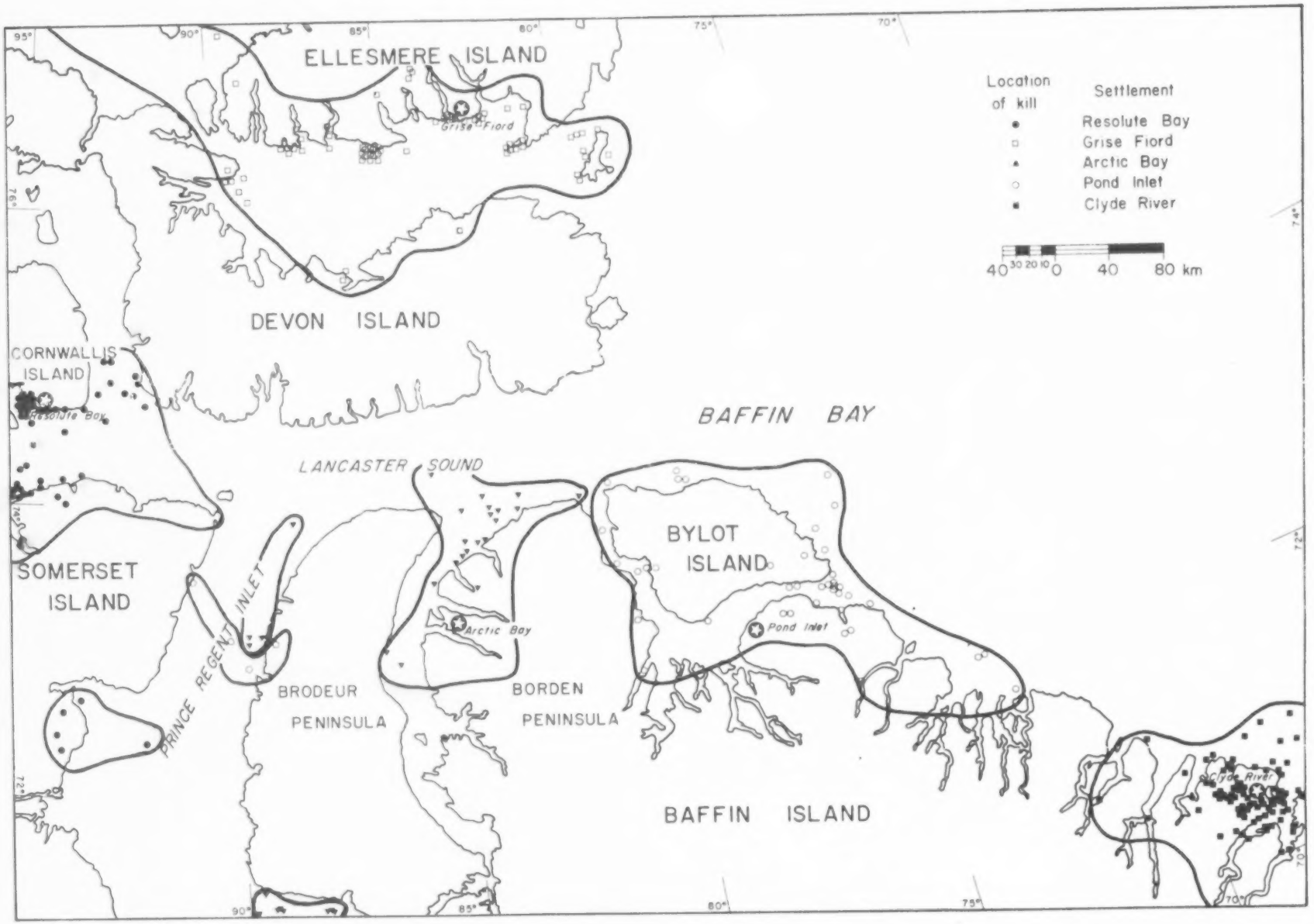

Fig. 15 Locations of hunter kills and hunting areas of Resolute Bay, Grise Fiord, Arctic Bay, Pond Inlet, and Clyde River, from 1976 to 1979.

Table 16. Chi-Square analysis of differences in hunting patterns based on hunter kill returns from 1976 - 1979.

Settlement	Sex	Oct./Dec.	Jan./May	$X^2_{05,1}$	Season of most kill
Arctic Bay	M	15	12	0.167	Equal
	F	8	2	1.800	Equal
Pond Inlet	M	16	19	0.129	Equal
	F	8	7	0.033	Equal
Grise Fiord	M	17	46	6.675*	Spring
	F	14	19	0.379	Equal
Resolute Bay	M	12	59	15.556*	Spring
	F	6	19	3.380	Equal
Clyde River	M	63	7	22.400*	Autumn
	F	41	1	19.048*	Autumn
All settlements	M	123	143	0.752	Equal
	F	77	48	3.364	Autumn

* Significant difference between autumn and spring.

Table 17. Sex ratio of the hunter kill sample from Arctic Bay, Clyde River, Grise Fiord, Pond Inlet and Resolute Bay based on the returns from 1976/77, 1977/78 and 1978/79 hunting seasons.

	Male	Female	Sex ratio	
Arctic Bay	22	12	2:1	$0.75<P(X^2_{05,1}> 0.0592)$
Clyde River	35	15	2:1	$0.50<P(X^2_{05,1}> 0.2511)$
Grise Fiord	63	33	2:1	$0.75<P(X^2_{05,1}> 0.0469)$
Pond Inlet	71	26	3:1	$0.75<P(X^2_{05,1}> 0.1684)$
Resolute Bay	69	43	2:1	$0.25<P(X^2_{05,1}> 1.2907)$
All settlements	260	129	2:1	$0.75<P(X^2_{05,1}> 0.0039)$

Table 18. Average prices in dollars paid to hunters and estimated total value for polar bear hides from Arctic Bay, Grise Fiord, Pond Inlet, Resolute Bay and Clyde River. Number of hides are in parentheses. (Adapted from Smith 1978, 1979).

	Quota	1975/76	1976/77	1977/78	1978/79
Arctic Bay	12	620 (5)	717 (3)	929 (7)	1,862 (4)
Grise Fiord	33	352 (19)			1,401 (14)
Pond Inlet	13	536 (9)	855 (10)	1,081 (18)	1,155 (18)
Resolute Bay	34	412 (5)	247 (5)	413 (2)	932 (22)
Clyde River	42	550 (2)	531 (40)	672 (37)	815 (40)
Average price		444	572	807	1,030
Estimated total value (Average price x quota)		59,496	76,782	108,144	138,052

have a chance to den. In all settlements male bears were selectively hunted (Table 17); however, some females are shot and an unknown number are undoubtedly pregnant. New regulations have recently been passed to delay the opening of hunting season to 1 December. By this time, most pregnant females will be denned and inaccessible to hunters.

The polar bear is an important economic resource to the local Inuit. Meat is used domestically and the sale of polar bear hides brought in an estimated $60,000 to $138,000 to the five communities annually for the last four hunting seasons (Table 18).

SUMMARY

1) More bears were encountered in the study area in 1979 than 1978. Reasons for the increase are unknown.
2) Polar bears were distributed during the spring along both coasts of Lancaster Sound, along eastern Devon Island, and along the northeast coasts of Bylot and Baffin Islands.
3) More bears were found along the south Devon Island coast than anywhere else in the study area. This trend was found in both years although localized differences in distribution and concentration were probably the result of varying ice conditions.
4) Polar bears appeared to favor roughened, landfast ice over floe edge.
5) Polar bears undoubtedly used the offshore floe ice but no bears were captured there.
6) During the summer, polar bears were found in deep bays with landlocked ice or on land. Land areas where bears have been seen or are suspected are the south and east coasts of Devon Island, the perimeter and coastal

mountain areas of Bylot Island, and the west, north, and northeast coasts of Baffin Island.

7) Bears marked and recaptured during late winter in succeeding years showed fidelity to the places they were originally captured. Females moved an average of 198 ± 96 km and males 167 ± 92 km from their place of original capture.

8) Few movement patterns were detected during this study. The most clearcut was a movement pattern to the east by bears captured during the summer and recaptured during the winter. It may be that as breakup proceeds, bears move with the ice to the west and then back again during the winter.

9) Short term movements of polar bears were variable in length. Bears did show a trend, however, toward moving along and remaining close to shore.

10) The bears of Lancaster Sound belong to the same subpopulation as those of Prince Regent Inlet, Barrow Strait, Wellington Channel, and Jones Sound (F Zone). There is also a connection between the bears of Lancaster Sound and those along northeast Baffin Island, at least as far as Clyde River. The relationship of Lancaster Sound bears to those of Greenland remains unclear.

11) Maternity denning appears to be widespread and sparse. Areas where newborn cubs were seen during April were Radstock Bay, Croker Bay, Cape York and Bylot Island.

12) Estimates of population size for eastern Lancaster Sound and total F Zone were 1031 and 1647, respectively.

13) The sex ratio of the capture sample for eastern Lancaster Sound was not significantly different from 1:1. However, the sex ratio for the entire F Zone bears was unbalanced in favor of females 0.554. The imbalance may be the result of selective hunting of males.

14) The calculated litter size for eastern Lancaster Sound and all of F Zone was 1.56 and 1.6 cubs/litter respectively. A small proportion of females bred for the first time in eastern Lancaster Sound at 3 years, but most began during their 4th year.

15) For all F Zone the weighted mean probability of parturition (the probability that a female would have a cub that year) was 0.210. The weighted mean natality rate (the number of cubs/female/year) was 0.336.

16) Eastern Lancaster Sound polar bears had a survival rate of 0.885, whereas the survival rate for all of F Zone was 0.871. We estimated that 172 cubs a year are born while 212 bears die. Table 19 summarizes the population information from this study and all of F Zone.

17) Polar bears yielded $60,000 to $138,000 to the people of the area for the last four hunting seasons.

Table 19. Summary of population and productivity information based on capture data from F Zone 1970-79 and eastern Lancaster Sound 1978-79.

	F Zone	Eastern Lancaster Sound
Population estimate	1647	1031
Mean litter size Coy	1.68 (59)	1.69 (16)
Yearling	1.58 (36)	1.29 (7)
2 yr-old	1.45 (11)	1.50 (2)
Weighted mean litter size	1.6 (106)	1.56 (25)
Weighted probability of parturition	0.21 (241)	0.139 (89)
Weighted mean natality rate	.336	0.217
Annual deaths*	212	119
Annual births*	172	65
Sex ratio all ages	0.554 female to 0.443 male	1 to 1
Coy	1 to 1	1 to 1
Breeding interval***	$\frac{1.6}{.336}$ = 4.76 yr.	$\frac{1.56}{.217}$ = 7.2 yr.
Survival rate	.871	.885

* For Lancaster Sound calculated by (1-Survival rate) X (Population estimate.

** For Lancaster Sound calculated by weighted mean natality rate X No. of breeding females in population.

*** Breeding interval = $\frac{\text{weighted mean litter size}}{\text{weighted mean natality rate}}$

IMPLICATIONS OF OIL DEVELOPMENT ON LANCASTER SOUND POLAR BEARS

If an oil spill occurs near the mouth of Lancaster Sound, oil will likely travel into Lancaster Sound and along the northeast coast of Baffin Island. The distance it penetrates into Lancaster Sound will depend on the season and prevailing ice conditions.

Polar bears would probably contact oil along open water or leads. In late winter and spring, depending on ice conditions, this would occur along the south coast of Devon Island, the north and northeast coasts of Bylot and Baffin Islands and the mid-Lancaster sound floe edge. In summer, bears would contact oil along the coastal areas of Devon, Bylot and Baffin Islands. We do not have data for fall and early winter, but we assume that this distribution is similar to that of late winter.

There may be yearly movements of bears associated with ice conditions. Bears probably move east offshore from Lancaster Sound into Baffin Bay, and our study suggests that there is also a westward movement which may be determined by the pattern and rate of annual ice breakup in Lancaster Sound. This could mean that many bears, except those that stay at Lancaster Sound summer retreats, would be out of the area if a mid-summer oil spill occurred. They would, of course, return to Lancaster sound as the ice reformed.

Our study showed that numbers of polar bears may vary widely from year to year in Lancaster Sound. This variation is probably related to ice distribution as well as the abundance and distribution of the bears' main food source, ringed seals. We cannot predict environmental conditions that cause large-scale movements of polar bears within the larger sub-population range. Therefore to determine if populations fluctuate naturally or as a result of industrial disturbance they should be monitored in the same years

as oil drilling takes place. This could be particularly important if a short-term change in population coincided with an oil spill.

With the exception of Baffin Bay and northeast Baffin Island, there is probably enough information now to assess long-term population changes which may result from an environmental disaster such as an oil spill. However more work is required to strengthen the present data base. For example, productivity estimates are low compared to other areas. This is probably because of small sample size. On the other hand, the population estimate of 1,000 bears for Lancaster Sound seems high for such a small area. We do not know if the bear population of 1979 was unusually high, but if our estimates are correct, Lancaster Sound is one of the most densely populated areas known. The population structure approximates that of other bear populations, but small sample sizes have produced gaps, particularly among the younger and older age groups.

Unless an oil spill or blowout occurs, it is unlikely that drilling one exploratory well would have much impact on polar bears. However longer term development must be considered. We feel that a major oil field development with all its associated facilities and activities would greatly affect polar bears in the area and lead to declines in numbers.

Onshore bases established in polar bears concentration areas will result in man/bear conflicts which inevitably lead to dead bears. Historically this has caused bears to decline in number or be extirpated in a large part of North America.

It is not known if polar bears will avoid spilled oil or refuse to eat oiled food items. It must be assumed, therefore, that contact with or ingestion of spilled oil will prove harmful.

A major oil spill would likely lead to the disruption of food chains. The sudden depletion of polar bear food stocks in Lancaster Sound would cause starvation as well as an increase of hungry bears creating problems in camps and villages.

Depending on how far west oil will spread and assuming the worst case of complete elimination of the polar bear population in Lancaster Sound, it is evident from this study that only a portion of the F Zone population will be affected. We speculate that polar bears from the unaffected portion will repopulate Lancaster Sound, probably within decades. However, this will occur only if the ecosystem returns to its pre-spill state and that hunting throughout F Zone is strictly curtailed to maintain breeding stock.

ACKNOWLEDGEMENTS

Funding for this study was provided by Petro-Canada Explorations Ltd. and some logistics support was obtained from Polar Continental Shelf Project. We appreciate the field assistance of B. Bergman and R. Predy of the NWTWS and Dr. D. DeMaster and M. Taylor of the USFWS. S. Buckles, Apex Helicopters Ltd., G. Webb and L. Dean, Kenting Helicopters, provided professional and efficient helicopter service. W. Calvert, J. Takahashi, W. Nixon and Henk Kiliaan, of the CWS, and A. Sutherland, NWTWS, did the lab analysis. Dr. I. Stirling, CWS, provided advice and backup support. J. Graves reviewed and improved the manuscript.

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